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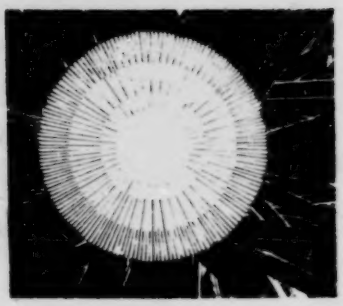

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COMMITTEE
ON THE CHALLENGES OF
MODERN SOCIETY

SOLAR ENERGY
PILOT STUDY

NATIONAL SOLAR HEATING AND COOLING PROGRAMS

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at the

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May 28 – June 1, 1979

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Edited by

Sheila Blum and Julia Allen
TPI, Inc.
5010 Sunnyside Avenue
Beltsville, Maryland 20705 USA

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ABSTRACT

This document is a compilation of status reports on the national solar heating and cooling programs of seventeen countries participating in the Committee on the Challenges of Modern Society's Solar Energy Pilot Study. These reports were presented in two special sessions of the 25th Congress of the International Solar Energy Society held in May 1979, in Atlanta, Georgia, USA. This information exchange activity was part of the two-year follow up (1978-1980) of the Solar Energy Pilot Study, which ended in October 1978.

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INTRODUCTION

The Committee on the Challenges of Modern Society (CCMS) Solar Energy Pilot Study was established in 1973 as a collaborative effort to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, industrial, agricultural and public buildings. The pilot study provided for the exchange of information on solar heating, cooling and domestic hot water systems in buildings, including the regular exchange of status reports on the national solar heating and cooling programs of participating countries. These reports were presented at Pilot Study meetings from 1974-1978, enabling government program officials and technical experts who attended the annual meetings to compare their own programs and activities with those of other countries and to note opportunities for expanding and strengthening them. Pilot study participants profited from the opportunity that this exchange offered to share experience and avoid duplication of efforts.

The Solar Energy Pilot Study ended in October of 1978, and like all CCMS pilot studies, it entered a two-year follow up period. Participants recommended a continued exchange of information on national programs, and suggested that the International Solar Energy Society (ISES) allow a special session on this topic at its next biannual meeting, the 25th ISES Congress in Atlanta, Georgia, USA in May of 1979. Having obtained the agreement of the ISES Board of Directors, Dr. Frederick H. Morse (the Pilot Study Director) and Ms. Sheila Blum (the Administrative Coordinator of the Pilot Study) organized the session with the cooperation of Dr. William Beckman (the ISES Conference Technical Program Chairman).

Seventeen CCMS countries* presented status reports on their national solar heating and cooling programs at two sessions of the ISES Congress. In addition to continuing the interchange among the member nations, the ISES presentations enabled a wider audience to learn of solar heating and cooling activities in these countries. The papers, which report progress and changes in program scope over the year since the last pilot study meeting, are compiled in this document.

Pilot study participants wish to express their appreciation to the ISES Board of Directors and Dr. William Beckman for allowing this exchange of information to take place.

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* CCMS representatives from Italy, New Zealand and Spain were unable to attend the ISES Congress, but each submitted a paper for inclusion in this report.

AUSTRALIAN PROGRAMME FOR SOLAR HEATING AND COOLING

W.R.W.Read
CSIRO Division of Mechanical Engineering,
Highett, Victoria, 3190, Australia.

ABSTRACT

Solar energy research, development and demonstration is continuing to expand in Australia primarily for thermal processes in domestic, commercial and industrial applications. The estimated annual expenditure is approximately $5.5 million.*

1. INTRODUCTION

The most urgent energy problem facing Australia is the need to develop alternative energy resources to replace oil for use in transportation and thermal processes for domestic, commercial and industrial applications. In 1976, estimates of Australia's primary energy consumption [1] showed that approximately 50% was supplied by oil, of which 70% was supplied from Australia's indigenous resources. Current estimates show that by 1987/88 [2] Australia will have to import about 60% of its oil requirements.

This demand for energy, plus the escalating costs of imported oils which are expected to exceed $2000 million by 1987/88, and the increasing dependence on overseas supplies, has caused both the Commonwealth and State Governments to increase substantially their support for solar research, development and demonstration. In May 1978 the Commonwealth Government established the National Energy Research Development and Demonstration Council, which in August called for applications for grants for solar R D & D, and it is anticipated that funds amounting to about $1.25 million will be made available this financial year. These funds are in addition to an estimated $3 million dollars already allotted to CSIRO, universities and others for solar programmes.

Over the past two years considerable impetus has been given by State Governments to the promotion of solar R D & D. In Western Australia $600,000 has been allocated to the Solar Energy Research Institute of Western Australia, while in Victoria the Victorian Solar Energy Research Committee expects to allocate $500,000 during this financial year. The South Australian Government has approved $400,000 for solar and related projects on the recommendations of the South Australian State Energy Advisory Committee, while the New South Wales Energy Authority has also received an allocation of funds for solar demonstration projects in that State.

Australia's vast coal supplies can meet most of its power needs into the foreseeable future, hence the predominance of the work in Australia relating to the utilization of solar energy is directed towards thermal processes including water heating for domestic, commercial and industrial applications, swimming pool heating, space heating and cooling, which also includes passive systems.

2. DOMESTIC HOT WATER

The most common use of solar energy in Australia is for domestic water heating. Following about 20 years of gradual development, the manufacture of solar water heaters has become an extensive and well-established industry in which increased emphasis is placed on mass production, improved performance in higher temperature ranges, a wider range of collector designs using a variety of materials such as aluminium, stainless steel and plastic materials and also improved cost effectiveness.

The number of domestic systems in Australia is increasing and is estimated to be in excess of 50,000 at the present time. While the economics of these systems are very attractive in some areas, in the large centres of population such as Adelaide, Melbourne and Sydney, the repayment period at present is typically 10 to 12 years. However, it is expected that this period will be reduced by the application

* $A 1.00 = $US 1.13 (20/7/79)

of improved production techniques and design concepts and also with increased costs of fuel and power.

(a) Programme

Generally speaking, domestic water is now in the field of commercial development and exploitation with competition in the market place stimulating continuing developments from within the industry itself. Some State Government instrumentalities have provided funds for particular commercial developments such as selective coatings of absorber plates and the use of alternative materials.

Of vital concern in the domestic programme is the extension and validation of collector testing procedures and the interpretation of the results. At the moment the bulk of the testing in Australia is carried out at the CSIRO Divison of Mechanical Engineering, although collector testing facilities are being established in all States.

(b) Standards

Closely allied to the testing programme is the establishment of Standards for Domestic Solar Hot Water Systems and the Standards Association of Australia's Committee CS28 is in the process of producing standards which cover design and construction, domestic system testing and performance and an installation code of practice. The installation code of practice has been recently printed and is now ready for distribution.

3. COLLECTOR DEVELOPMENT

It is expected that improved economics in solar systems can be achieved by the use of solar collectors as an integral part of the roof cover, and the CSIRO Division of Mechanical Engineering has developed a collector concept which might be used for this purpose. One system of 1000 m^2 for pool heating is scheduled for completion within a few months, while another of 720 m^2 for low temperature industrial process heating is under consideration.

A wide range of research activities relating to improved collector design are in progress within CSIRO and universities. The projects include high temperature collectors fitted with convection suppression devices, evacuated tubular collectors, and designs using heat pipes, flat-plate collector testing and performance evaluation, concentrating and reflector systems, and selective surfaces. In CSIRO the work is being undertaken by the Divisions of Mechanical Engineering and Mineral Chemistry, while the universities involved include the Universities of Melbourne, Adelaide, Western Australia and The Australian National University, The Sydney University, The James Cook University of Northern Queensland and the Universities of Queensland and New South Wales. Colleges of Advanced Education which are also involved include Capricornia College of Advanced Education, The New South Wales Institute of Technology and the South Australian and Western Australia Institutes of Technology.

In recent years there has been a dramatic increase in the production of flat-plate solar collectors in Australia, having increased from 7,000 sq m in 1972/73 to 63,000 sq m in 1977/78, an average increase of about 60% pa. Although the local market is continually expanding, substantial export markets have also been established, and in Japan arrangements have been made for Australian collectors to be manufactured under licence.

4. INDUSTRIAL PROCESS HEATING

Information provided by the Commonwealth Department of Minerals and Energy has shown that for 1974-75 the total primary energy consumption was 2.8 EJ of which 40% was consumed in the manufacturing industry, and about 14%, including 10% for electric power production, was required in the domestic sector. A survey in food processing industry (Proctor and Morse 1975) [3] indicated that about 89% of the energy used in that industry was in the form of heat while the remainder was used as electricity. Practically all of the heat was used at temperatures below 150°C, and about 70% of this was below 100°C. Although limited to a relatively small number of establishments they included meat processing, beer and soft drink production, milk and milk products and fruit canning.

The survey also revealed that about 60% of the energy used was supplied by oil and over 90% of the heat required was confined to six processes namely cooking 25%, bottle washing 14%, pasteurization 18%, sterilization 8%, water heating 13% and product separation 18%. It is apparent that in food processing there are many industrial applications are already within the range of conventional solar water heating systems; however further surveys are required to determine the energy and temperature requirement of other industries.

(a) Programme

If solar energy is to be used as a major energy resource in industry much more information is required concerning the integration of solar systems with the existing industrial processes. Hence, the

need to design, install and operate real systems in order to obtain first hand experience of the problems involved. These installations also provide the opportunity to monitor and evaluate the system performance, to analyse the overall costs involved and to produce a data base which can be used for the design of future systems. These considerations have led to a solar industrial demonstration programe being implemented by CSIRO, and the two systems which are currently now in operation are described in the following Sections.

(b) Queanbeyan, New South Wales

The first of these is a can warming installation located at a soft drink manufacturing plant at Queanbeyan in New South Wales and was commissioned in January 1977. In the process, filled cans of soft drink pass through a can warmer where they are heated by sprays of hot water to raise the can temperature from 3°C to a temperature above the ambient dew point to prevent moisture condensing on the cans before packaging. This system was described in detail in the CCMS Report submitted in Dusseldorf in 1978 by Mr. R.N.Morse. The system has now been in operation for a period of 2 years and the most reliable performance data covers the period September 1977 to February 1979. This can be summarised as follows:

TABLE I

Total energy collected	307 GJ
Energy delivered to process	222 GJ
Utilization efficiency	72%
Collector efficiency	32%
Solar fraction of the load	44%

The system has operated very satisfactorily although the heat losses are higher than expected.

(c) Adelaide, South Australia

Another system has been installed at the South Australian Brewing Company in Adelaide, South Australia, is used to provide some of the heat for a beer pasteurizer. The installation was designed by Simpson, Kotzman and Partners Pty. Ltd., Consulting Engineers, in collaboration with the CSIRO Solar Energy Studies and the South Australian Brewing Company. The system consists of 178 sq m of Beasley industrial collectors arranged in 3 arrays, 2 of which are made of double-glazed units totalling 114.5 sq m, and the third of 63.5 sq m are single-glazed, thus enabling the performances of the 2 types of collectors to be compared simultaneously.

Because of the roof design it was necessary to install a separate superstructure for supporting the collectors. It was also necessary to separate the collector arrays in order to ensure satisfactory load distribution on the roof.

Two tanks having a combined capacity of 52,000 ℓ and available at the Brewery were used to store the solar heated water. One is of mild steel construction and the other stainless steel; both are insulated with 165 mm of weather-protected polyurethane foam.

The solar system is used to supply hot water to the first heating section of the pasteurizer in which the water is maintained at a temperature of 65 ± 1½°C. Conventional heating is by means of steam injected directly into the sump at 700 kPa from a gas fired boiler. Heat meters have been installed in the solar circuit to enable the performance of both the double-glazed and single-glazed collectors to be determined. Similar heat meters are provided in the process circuit to monitor the heat provided from the store to the process, while the steam supplied to the pasteurizer is recorded on an orifice meter. Two pyranometers provide daily total global radiation in the plane of the collectors and a multi-point recorder monitors up to 24 temperatures at various selected points within the system.

(d) Performance

Following a period of shutdown for maintenance, the pasteurizing system became fully operational in September 1978, and a summary of performance to date is shown in the following Table.

TABLE II

Total energy collected Oct.1978 to Apr.1979	317 GJ
Total energy collected Jan.1979 to Apr.1979	182 GJ
Energy delivered to the process	125 GJ
Utilization efficiency	69%
Collector efficiency	41%
Solar fraction of load	3.6%

Both of these systems were the result of collaboration between CSIRO and the companies concerned, with CSIRO being responsible for the supply of the solar system, while the company contributed in both funds and resources for the work entailed in the process circuit. The experimental programme of these installations runs for a nominal period of 2 years, at the conclusion of which the companies have the option of purchasing the system based on the capitalised value of expected energy savings over the following 8 years.

During the past year this programme has been extended to include tripartite agreements between the CSIRO Solar Engineering Unit (formerly Solar Energy Studies) with the Solar Energy Research Institute of Western Australia and the Energy Authority of New South Wales, together with industrial organizations in those States. In Western Australia a bottle washing installation is being designed for a soft drink factory while in New South Wales the installation will provide process water for an abattoir. These are expected to be completed early in the next financial year.

Funding arrangements between the Commonwealth and State Government Instrumentalities are negotiable, although generally they are on a dollar for dollar basis. CSIRO Solar Engineering Unit has also collaborated with the Victorian Solar Energy Research Committee in the design of a milk pasteurizing installation and this system is expected to be commissioned within the next few months.

It is anticipated that the demonstration programme will be extended to cover a wider range of applications which hopefully include other processes which are outside the food processing industry.

5. SPACE HEATING AND COOLING

Because of the reasonably temperate climate experienced in Australia's main population centres from Brisbane to Adelaide, the need for continuous winter heating and summer cooling is uncommon and in domestic applications it is generally difficult to justify full air conditioning. However, depending on the particular location, heating and/or cooling is generally required for several months of the year, the precise requirements being governed by the local climate.

With the increasing costs in fuel and a growing awareness for the need for energy conservation, greater consideration is now being given, particularly in new building designs, to the possible use of solar energy for heating and cooling in either active or passive systems.

While there is not a coordinated programme in solar heating and cooling in Australia, work is proceeding in a number of organizations with experimental demonstration type systems. These activities may be summarised as follows.

1. Solar air conditioning using lithium bromide absorption units.

   Eldridge Medical Centre, Bankstown, New South Wales 50 ton refrigeration, collector area 400m²

   Commonwealth Administrative Services Building Townsville

   Kounis Manufacturing Industries Building, Perth, WA 25 ton refrigeration, collector area 268m²

   Gas and Fuel Building, Melbourne, Victoria

   Western Australia Institute of Technology, Perth, WA

   BHP residence, Groote Island, WA

   Szokolay residence, Queensland

   The Administrative Services Building Townsville has been fully instrumented and a conventional water chiller has also been installed to enable long term comparisons of performance to be obtained. It is anticipated that performance data and operating experience from the other systems will also be made available to assist in future system designs. The current costs of solar air-conditioning restrict the use of these systems to experimental and demonstration systems. In Australia domestic two ton systems range in price from about A$15,000 to A$20,000, while commercial type installations vary from about A$5,000 to A$6,000 per refrigeration ton.

2. Open Cycle Air Heating and Rock Pile Storage. These systems are generally a combination of solar air heaters with rock pile storage with the possibility of utilizing evaporative cooling in the summer operation.

   CSIRO Laboratories, Laboratory building Highett, Victoria.

   CSIRO Low Energy Consumption House, Highett, Victoria.

   SERIWA Solar House No.Q1, Perth, WA.

   The University of New South Wales, Solar Experimental House, Mark 1, Fowler's Gap, New South Wales

   Szokolay House, Brisbane, Queensland

   Passive System Insectiary Waite Institute , Adelaide S.A.

Other work in progress includes the following:

   Melbourne University, passive wall

systems, solar boosted heat pumps and air-cooled absorbption systems.

Deakin University, passive wall systems.

CSIRO, Division of Mechanical Engineering, dehumidification for open cycle systems.

Bos All Solar House, Pearcedale, Victoria.

6. SWIMMING POOL HEATING

The relatively low temperatures required for swimming makes pool heating an ideal application for solar energy. Estimates of the Swimming Pool Assocation suggest that there are over 850,000 pools in Australia and increasing at the rate of about 50,000 per annum. Of the total, between 1,000 and 1,500 are indoor and outdoor municipal public pools, the remainder being domestic inground and above ground installations. While it is known that there is an increasing demand for solar heating of pools for both domestic and public installations, it is difficult to obtain accurate figures relating to the numbers installed, although the Swimming Pool Association estimate that less than 1% of new systems are heated with solar energy. As the figures quoted are essentially subjective estimates they can only be taken as a guide to convey current trends.

From information provided by a leading manufacturer in Victoria and one in New South Wales, it would appear that about 500 domestic systems using conventional collectors are installed annually and the numbers are increasing at the rate of about 30% per annum. Of these its is believed that about 10% of the solar heated pools are also fitted with covers. It is virtually impossible to estimate the numbers using other means such as various configurations of plastic piping or pool covers only.

Of considerable importance is the increasing interest of State Governments and municipal authorities in the use of solar heating of public indoor pools. Four installations were funded by the NSW Department of Sport and Recreation last year and another twenty-five 25 m indoor pools are planned in the near future. In Victoria the Victorian Solar Energy Research Committee has also funded 2 installations and it expected that these numbers will increase annually as funds become available. At the present time there are 6 municipal installations in Victoria at the design stage, proposing to use solar heating. Where solar systems cannot be installed immediately plumbing connections have been provided to permit the installation at a later stage.

Further developments in pool heating are predominantly in the manufacturing and commercial fields. However, an important development which should improve substantially the economic viability of pool heating is the integrated collector concept developed by the CSIRO Division of Mechanical Engineering. The 1,000 sq m installation funded by the Victorian Solar Energy Research Committee is being installed at the present time and it is expected to provide about 25 GJ of heat per annum for every $1,000 invested in the installation. This compares with about 10 GJ per $1,000 for domestic hot water and 6 GJ per $1,000 for some industrial processes.

Hence, it can be seen that solar technology, especially for thermal applications, is expanding in Australia, however, much more has to be done if solar energy is to become a major alternative resource. Although in its early stage of development, all the indications are that the industry will continue to expand and solar energy will become economically viable with improved manufacturing and design techniques and particularly as the costs of gas and oil increase. The increasing interest of State Governments is most encouraging and it is expected that this will provide considerable stimulus to the utilization of solar energy in Australia.

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THE BELGIAN SOLAR HEATING R & D PROGRAM

Prof. A. PILATTE
Faculte Polytechnique de Mons
Laboratoire de Thermodynamique
Boulevard Dolez, 31,
7000 Mons

PHASE I.

In 1975, the Belgian Government announced a BFr 240 million* 3-year program of research and development in energy savings. It has been a major challenge to the Belgian scientific potential to elaborate new energy options. The program aims, on the one hand, to supply, by means of technical and economical research, the necessary data to make political decisions; and on the other hand, to put the research teams necessary for further work at the disposal of government agencies. The whole program, which is coordinated by the Ministry of Scientific Research, involves about 20 research groups at universities and private and public research centers.

Both solar heating and photovoltaic conversion were included and received approximately 15% of the total budget.

The solar heating program was carried out at two university laboratories, one at the Faculté Polytechnique de Mons, the second at the Katholieke Universiteit. Both liquid and air systems have been investigated for water and space heating applications. At the same time an economic analysis was performed.

Thermal conversion of solar energy is easily realized by use of flat plate collectors, the general technology of which is well-known. The thermal performances we can expect are however very much dependent on the design and the operation and climatic conditions. Furthermore, the solar heating loops, composed of collectors, storage tank, auxiliary heating, regulation system and components, must be optimized. It was therefore necessary to develop a program of R & D on the components of a solar system based on data from real climatic conditions, in order to provide useful data to the governmental agencies, manufacturers and users. It was also necessary to develop a solar scientific potential capable of participating in international cooperation in the field of solar energy and able to evaluate the results of the research and of the various demonstration programs on a national level.

*1 Bfr = US $ .034 (July 20, 1979)

1. Analysis of the thermal performance of collectors.

Two experimental test stations have been built in Mons and Leuven. They are equipped with all the necessary meteorological and thermal equipment as well as regulating, recording and computing facilities. The experimental data collected from these 2 stations are used for several purposes:

a) They serve to validate the simulation programs of components, and of systems when available, by comparing the estimated and measured performances;
b) They allow the establishment of plots giving the thermal efficiency of solar collectors according to the existing standardized methods (ASHRAE, BSE, CEC, etc.);
c) Finally, the analysis of these data provides useful indications about the influence of parameters for construction and therefore about the means to improve collectors.

2. Simulation programs.

As it is impossible to analyze experimentally the influence of every characteristic parameter on the thermal performance of a solar system in every possible operating condition, simulation programs must be developed. They must be validated against real systems in as many cases as possible; therefore there is a need for a well-instrumented test station. These simulation programs are a milestone in solar research. They allow the calculation

and therefore the optimization of systems.

The following programs for components and complete systems have been developed and are being undertaken:

a) liquid flat plate collectors (1 or 2 covers, black or selective absorber...);
b) air collectors;
c) domestic hot water heater with forced circulation (several arrangements of components);
d) domestic hot water - thermosiphon;
e) solar heating systems for houses using liquid flat plate collectors, floor heating systems. The auxiliary heating system is either direct (oil, gas, electricity) or uses a heat pump. Various storage systems have been studied;
f) air heating systems using air collectors and contained storage.

The results of these computations were presented at the end of the 3 year program in 1978, and will be published by the Ministry of Political Science in a form suitable for its users.

3. Meteorological data - Definition of a reference year.

In estimating the thermal performances of components or systems from simulation programs, it is necessary to use representative climatic and radiation data. Therefore a test reference year has been composed from hourly measured data (direct, diffuse, global, ambient t^0, wind speed) over 18 years. The selection method developed by the Royal Institute of Meteorology is a purely mathematical one and has been described by Dogniaux et al.

4. Integration of solar equipment to solar houses.

The technical and architectural problems of the integration of solar equipment to houses have been met during the first phase of the national program by the study of a detailed project of a solar house. This house, which is to be built in Mons during the second phase of the solar program (1978-1982) will be a demonstration and experimental tool for the research teams involved in the National Program. The first 3 year phase of the National Program was considered to be an initial program and was supposed to set up research teams and research tools and provide objective data needed for political decisions. Aside from these results, the program has had indirect results, which are far from being negligable, in increasing the sensitivity of people to energy problems. The research teams of the solar program have had hundreds of contacts with individuals, professionals (architects, builders), governmental housing agencies, and medium and large industries. Within a few years, the public attitude towards solar energy has changed drastically, from incredulity to real interest. One has to admit, however, that the market for solar equipment is developing extremely slowly in Belgium. There are 2 main reasons:

a) A lack of confidence in technology on the part of architects and heating-system installers who are the most appropriate persons to push this industry forward. One must therefore develop information and build demonstration equipment.
b) The extra cost needed for solar energy utilization. One could help individuals by fiscal aids, but continuation of the research effort to develop cheaper reliable components and support of the development of manufacturing processes leading to cost reduction is a more direct method.

In any case, the Government and the public agencies have an essential role to play by using solar energy in their own administrative buildings, schools, and sport centers, by helping the development of a Belgian solar industry, and by subsidizing loans for solar investments.

It is difficult to predict the importance of solar energy in Belgium in the near future. However, in order to help Belgian solar firms to compete with foreign firms, the Belgian government has begun a new 4 year solar program at the end of 1978.

5. Economic analysis.

The conclusion of this analysis was that, under present conditions, solar energy is about twice as expensive as traditional fossil fuels for heating purposes. The following solar technologies are classified by increasing costs:

1. Hot water only, collective use (at least six families);
2. Heating;
3. Hot water, individual use.

The following table summarizes costs for these systems over a 10-year period without maintenance costs, and at an interest rate of 10%.

	Over cost per square meter	Performance (kWh/m²/year)	Cost per kWh (BF)
Hot water (individual)	8000 BF	350 kWh	2.77
Hot water (collectivity)	5000 BF	350 kWh	1.73
Heating	4800 BF	250 kWh	2.33

6. International cooperation.

The solar research teams of the National Program participate in international programs. Belgium is active in Task I (simulation programs), Task III (collector testing) and Task V (radiation data) of the IEA Solar Heating and Cooling Program. Belgium has received contracts from the European Communities to participate in the CEC program actions A and F (solar heating, radiation data and collector testing). Furthermore, in October 1977, Belgium decided to contribute to the construction of a solar power system in Almeria (Spain). Many companies in Belgium have shown interest in this project and are willing to participate in its construction.

PHASE II (1978-1982).

The second phase of the National Program has been prepared taking into account the following factors:

- The overall energy and economic situation has changed since 1975.
- The government has decided to develop a new industrial policy and it is possible that the National Program may contribute by looking at new opportunities in the field of production and utilization of energy which engender economic activity and create employment.
- Budgetary constraints limit the amount of money devoted to R & D.

Therefore new research projects have been designed to conform to research, energy and industrial policies. Each technology under development goes from laboratory research to experimentation and the demonstration program, all of which have a close connection with industry, in order to help future industrial development. The second phase is a 4-year program, starting September 1978, and coordinated by the Ministry of Scientific Research. Their total budget is of the order of 850 million BFr with about 250 million for the solar part. Its main tasks are:

- Modeling of the national energy system.
- Social costs.
- Energy savings in buildings.
- Solar energy in buildings.
- Heat recovery.
- In ground heat storage.
- Evaluation of coal reserves and analysis of their exploitation costs.
- Photovoltaics.

At the end of the first 2 years the Coordination Committee will evaluate the results and will make proposals according to the conclusions of the research teams and the work already performed. At the same time, it will analyze the international R & D program in order to modify, if necessary, the Belgian program so that it can contribute to the international cooperation.

The results of the first phase of the solar heating program indicate that in order to insure economic feasibility of solar systems and therefore to have a rapid development of the market, one has to optimize materials for components and their dimensions in a system. More work is necessary to modify construction practices in residential buildings in order to save as much energy as possible, minimize investments, and integrate solar technology in buildings.

Belgian Solar House.

Since mass production is necessary to decrease solar systems costs, it seems obvious to promote the use of solar heating systems by builders. Builders are reluctant to use solar systems because:

- the market is too narrow;
- technologies and design methods are poorly understood;
- durability and reliability are not proven.

It is, therefore, necessary to have a "reference solar house" in which complex and optimized solar systems can be studied. The cost of the energy produced by a solar system can be determined from data on its thermal performance. The Belgian Solar House will be a laboratory house, built taking into account the architectural and architectonic constraints caused by the adoption of solar heating. It will also be a tool to study the means and the materials to be used in reliable, durable and marketable components. The solar house, designed for Belgian conditions, will allow the validation of theoretical studies and will test the validity of various calculation methods for solar heating systems. The construction of the house should start this year. It will be located in Mons.

Solar collectors.

Further work on solar collectors (liquid and air) and on systems using these 2 types of collectors is planned in the second phase. Projects include air collectors associated with a heat pump; liquid collectors that work at t^0 lower than ambient t^0 during the winter months; durability tests, development of

selective surfaces by means of pyrolytic methods.

Solar pilot facility.

As part of the solar heating and cooling program of the Commission of European Communities, Belgium has decided to fund 50% of the cost of a solar pilot test facility to be built in Leuven. This project has as initial objective the validation of computer programs to model the performance of solar heating systems. It consists of a real solar system with the collectors subject to actual weather conditions and the system load provided by a simulator. The advantages of this test facility are that all the parameters affecting the performance of a solar system can be monitored and controlled; this is not the case in a house.

Budgets devoted to energy research by the Belgian Ministry of Scientific Policy.

	R-D Energy	Million BFr		%	
		1977	1978	1977	1978
national level (a)	nuclear	2095.3	2287.7	89.5 %	81.2 %
	non nuclear	219.9	429.7	10.5 %	18.8 %
international level (b)	nuclear	1077.8	1295.4	88.7 %	90.3 %
	non nuclear	122.2	126.5	11.3 %	9.7 %
Total (c = a + b)	nuclear	3173.1	3583.1	89.2 %	84.5 %
	non nuclear	342.1	555.2	10.8 %	15.5 %
	Total	3515.2	4138.2		

Energy R & D expenses in 1977 (global, nuclear and new sources).

	Innabitant	R-D Energy	R-D Energy per innab.	R-D nucl per innab.	New energies
	10^6 innab.	10^9 BFr	BFr/inhab.	BFr/inhab.	BFr/innab.
B	9.818	3.515 (a)	358 (b)	323 (c)	35
S (d)	8.219	2.051	249	77	182
NL (d)	13.770	4.812	349	237	182
F (e)	52.918	16.644	314	234	80
D (f)	61.531	22.545	366	262	104

B - S - NL - F - D : countries.

Sources : (a), (b), (c), (d), (e) SPPS.

(d) I.E.A. National Energy R-D programme reviews - Paris.

(e) Ministère de l'Industrie, du Commerce et de l'Artisanat - Paris.

(f) Bundesminister für Forschnung und Technologie - Bonn.

CANADA'S FEDERAL SOLAR ENERGY PROGRAM

R. M. Aldwinckle, Coordinator,
Solar Energy Project,
National Research Council of Canada
Ottawa K1A 0R6

ABSTRACT

Begun in 1975, the Canadian solar energy program has been managed since late 1977 by the Solar Energy Project of the National Research Council of Canada. The budget has grown from $2 million in fiscal '77 to $9.5 million* in the current fiscal year. The main thrust of the program is to develop solar heating technology suitable for Canadian conditions and to insure a Canadian industrial capability in the solar field. The program comprises: a) fundamental solar studies; b) systems trials in a wide range of conditions across Canada; c) industrial product development and d) research and development in photovoltaics. Current federal incentives are directed toward providing a guaranteed market for Canadian solar products and toward strengthening the capabilities of Canadian solar manufacturers to supply these markets.

1. INTRODUCTION

The Canadian federal solar energy program received its impetus from the "oil crisis" of 1973. Canada is fortunate in having still abundant indigenous supplies of conventional fuels, but the events of 1973 brought into focus as never before the essential vulnerability of an economy based on these finite sources of energy. In spite of this, the solar program has had something of a struggle for credibility; and its very existence is a tribute to the few far-seeing individuals - both in and out of government - who recognize that sooner or later Canada must depend upon solar energy for a respectable proportion of its energy needs.

The immediate thrust of the Canadian program has been to develop technical capability in the solar heating field. Some thirty percent of current energy use in Canada goes into heating living and working space. Research and development is also being conducted to develop economical and efficient photovoltaic cells, though the time-frame for this work is of longer duration.

The present paper summarizes briefly the main objectives of the Canadian federal program, identifies the principal departments and agencies contributing to the program, outlines the organization and budget and describes some of the principal program elements.

2. PROGRAM OBJECTIVES

The objectives of the federal solar energy program in Canada may be summarized as follows:

(a) to conduct research and development in the field of solar heating in order to develop solar heating systems adapted to Canadian conditions.

(b) to establish codes, standards and specifications for the manufacture, installation and operation of solar heating systems in Canada.

(c) to develop a Canadian industrial capability in the solar field, including design and manufacture, installing, operation and maintenance.

(d) to encourage development of a domestic market for solar design, equipment, installation, and service.

3. CURRENT ORGANIZATION OF THE PROGRAM

The interdepartmental Committee on Energy R & D, which was established by Cabinet decision subsequent to the oil embargo of 1973, has evolved to its present status as a Panel on Energy R & D chaired by the Assistant Deptuy Minister, Science and Technology, Energy, Mines and Resources. This Panel (PERD) performs the following functions:

(a) reviews federal energy R & D activities;

*$1 Canadian = $ US .8589 (July 25, 1979).

(b) develops and implements a coordinated federal program on energy R & D;

(c) advises Treasury Board on the allocation of funds for energy R & D;

(d) coordinates energy R & D activities in the Federal Government, including the federal contribution to federal, provincial and international initiatives;

(e) provides for the exchange of information on energy policy and strategies which would affect the direction of federal energy R & D programs.

4. THE SOLAR R AND D PROGRAM

The solar R & D program is administered by the Solar Energy Project of the National Research Council and comprises 10 sub-programs, identified by the codes 4.2.1 to 4.2.10. These are outlined briefly as follows:

4.2.1 Fundamental Studies

These are directed by the Division of Building Research of the National Research Council. Their objective is to gain technical information required by builders, designers, manufacturers, suppliers, and building owners on the uses and limitations of solar heating in Canadian buildings. To date, a number of studies have been completed and published and others are in progress. A large number of these studies were or are being contracted out to consultants or to university research resources:

(a) Feasibility Study on Application of Solar Heating Systems in Canada.

(b) Feasibility Study on Application of Solar-Assisted Heat Pump Systems.

(c) Feasibility and Strategy Study on the Solar "Mini-Utility" System.

(d) Proof-of-Concept Designs.

(e) Assessment of Available Solar System Computer Simulation Models.

(f) Study of In-ground Heat Storage

(g) Study of Insulation Methods for In-ground Heat Storage Units.

(h) Study of Low-Temperature Space Heating Systems.

(i) Study on Physical Conditions of Existing Solar Heating Installations.

(j) Formatted Reports on Solar Projects.

(k) Development of Collector Ranking Method.

4.2.2 Solar Energy Resource Assessment

The Atmospheric Environment Service of the Federal Department of Fisheries and the Environment gathers data on direct, diffuse and global radiation integrated over the solar spectrum (i.e. not expressed as a function of wavelength) for all regions of Canada at hourly intervals. The data base thus obtained is available for the design of solar collectors and systems.

Because solar collectors, particularly photovoltaic cells, are wavelength sensitive, it is necessary to know the distribution of the energy in sunlight as a function of wavelength (spectral distribution) for all regions of Canada at any time of the year. The NRC Solar Energy Project funds a program to measure the solar spectrum.

Canada participates in the International Energy Agency Tasks IV and V on the "Development of an Insolation Handbook and Instrumentation Package" and the "Use of Existing Meteorological Information for Solar Energy Application".

4.2.3 Advanced Scientific Projects

This subprogram is conducted by Solar Energy Project, N.R.C. The work covers two areas:

(a) Photovoltaic Devices and Systems. The objectives are to develop low-cost photovoltaic devices (solar cells) suitable for operating under Canadian climatic conditions and to ensure that the manufacture of such devices can be carried out in Canada, and

(b) Photochemical Devices and Systems. The objective is to develop devices or systems that use sunlight to produce photochemical reactions leading to one of the following: (i) production of electricity, with or without storage; (ii) production of hydrogen from water. The hydrogen would be stored and used as fuel to replace natural gas and other fuels.

4.2.4 Industrial Technology and Product Development

This subprogram is administered by Solar Energy Project, N.R.C. R & D contracts are of three basic kinds:

(a) Infrastructural - generating technology of value to the whole industry.

(b) Development of commercial products that will be reliable, durable and cost effective.

(c) Exploratory - investigating new ideas.

Work is done under contract by universities and private firms including: Concrete tanks for hot water storage; Study of phase change storage; Investigation of ceramic concentrating collector; Investigation and development of concentrating flat plate collector; Study of heat pipe technology; Simplified method of sizing solar collectors; Concentrating collectors for industrial use; and Packaged domestic hot water systems.

4.2.5 Systems Trials

This subprogram is the largest to be administered by Solar Energy Project. It has the following main objectives:

(a) To obtain data on the performance and cost-effectiveness of solar systems in providing space and hot water heating;

(b) To indicate the problems that are encountered in the design, installation, operation, and servicing of solar systems in Canada;

(c) To provide visible demonstrations to the public;

(d) In 1976/77 trials were begun on solar heating systems in single family residences; In 1977/78 trials were begun on solar heating in multi-family units; and in 1978/79 trials were begun on hot water heating for commercial applications. At the present time more attention is being paid to passive applications.

4.2.6 Agricultural Applications

Administered by the Canadian Department of Agriculture, the subprogram emphasizes improvement of the energy efficiency of greenhouses, and the application of solar energy to agricultural processes. The greenhouse program is striving for a 95% reduction in greenhouse fuel heating costs compared to conventional single-glazed glass greenhouses.

In 1979/80, the program will emphasize solar energy utilization in calf housing, farrowing barns, and poultry broiler buildings. It aims to reduce heating costs by at least 30% by 1983. The program will also investigate the application of solar energy to food processing.

4.2.7 Solar Heating of Commercial Buildings

Administered by the Department of Public Works, this subprogram has the objective of establishing the technical and economic feasibility of using solar energy for heating (and/or cooling) of commercial buildings in Canada, and to develop analytical aids to be used in determining this feasibility.

4.2.8 Monitoring

Originally conducted by the Division of Building Research N.R.C., this subprogram is now largely administered by the Solar Energy Project. Experience has shown that it can take over a full year to install and commission a properly functioning monitoring system. This subprogram, which is an essential adjunct to the Systems Trial (Subprogram 5) attempts:

(a) To accumulate data on the performance of solar heating systems in a variety of building types under Canadian climatic conditions;

(b) To analyze these data; and

(c) To use these data to verify analytical tools and give direction for future design criteria, industrial product development and systems trials.

4.2.9 Test Methods and Standards

This subprogram is conducted jointly by the Division of Building Research and Solar Energy Project. Its objectives include:

(a) Develop test methods and standards appropriate for Canadian conditions;

(b) Permit the objective comparison of the thermal performance, the reliability and the durability of components used in solar systems; and

(c) Ensure that adequate test facilities are available as required.

The Federal Cabinet directed NRC to accelerate the establishment of solar equipment performance standards suitable for Canadian conditions. This work is underway through a contract to the Canadian Standards Association.

Indoor simulation of solar radiation appears necessary in the Canadian climate so that solar collectors can be tested under controlled environmental conditions. Plans are underway to construct an indoor test facility for solar collectors using a single-source light. Canada participates in the IEA Task III "Performance Testing of Solar Collectors".

4.2.10 Information and Liaison

This subprogram is conducted by Solar Energy Project, N.R.C. Its objectives include:

(a) Establishment of a working system for collecting, organizing, and distributing technical information in the field of solar energy;

(b) Establishment of a National Renewable Energy Data Base; and

(c) Maintenance of contacts for the useful exchange of information with other programs, both national and international.

As mentioned before, a major effort within the scope of this last objective has been participation in tasks of the IEA Solar Heating and Cooling Programs.

5. BUDGETS

Table 1 summarizes the expenditures and approved budgets for the last three years, indicating the very rapid growth of the R & D program. Current predictions indicate that federal expenditures in this field will remain at the $9-10 million level for the next 2-3 years. Eventually, expenditures should decrease as problems are solved and the private sector takes over federal initiatives.

A total of 15 person years has been allocated to the Solar R & D program, and staff grouping follows the lines of the subprograms just described. The program is administered by its Coordinator, Solar Energy Project, who reports directly to the Energy Project Coordinator at divisional level within the National Research Council. Figure 1 shows the organigram of staff grouping for the federal R & D program.

6. OTHER FEDERAL INITIATIVES

In July of last year the Canadian Government announced several new programs designed to foster and expand the use of renewable energy, principally solar. These programs are involving major effort on the part of both Government and the fledgling solar industry. The following programs are underway:

(a) PASEM: a program of assistance to solar energy manufacturers, involving grants of $300,000 to each of ten solar manufacturers selected from a group of 25 competitors to assist in developing designs and production facilities to meet the growing demand.

TABLE 1. EXPENDITURES AND BUDGETS, SOLAR R & D PROGRAM
(thousands of dollars)

Solar Energy Subprograms	1977/78 (Expenditure)	1978/79 (Expenditure)	1979/80 (Approved)
1. Fundamental Studies	275	310	480
2. Solar Energy Resources Assessment	167	255	1,204
* DFE/AES	(124)	(779)	(779)
3. Advanced Scientific Projects	105	650	880
4. Industrial Technology and Product Development	300	1,424	2,058
5. Systems Trials	310	1,010	1,960
6. Agricultural Applications	-	370	274
7. Solar Heating of Commercial Buildings	-	65	192
8. Monitoring	405	620	1,180
9. Test Methods and Standards	220	370	805
10. Information and Liaison	44	320	510
Staff and Operational	160	558	767
Total	1,986	5,952	10,310

*These funds are allocated directly the the Atmospheric Environment Service of the Department of Fisheries and Environment.

(b) PUSH: a program to purchase and use solar heating equipment in federal buildings, involving the graded expenditure of $125 million of federal funds over the next five years in order to guarantee a market for solar manufacturers. It is foreseen that in that period of time the technology will become sufficiently established that public demand for solar systems will be able to absorb the production from solar manufacturers.

(c) Federal/Provincial: $114 million of federal funds has been committed for joint federal/provincial projects that are to demonstrate the feasibility of solar applications in a number of areas. In most cases, federal funds will be matched by funds from the provinces.

(d) Other federal projects such as the Low Energy Building Design Award, LEBDA, are smaller in scope; but are intended to increase the visibility of work in the area of renewable energy and convervation.

(e) A federal allotment of $14 million is to be spent on solar R & D over the next five years in support of the PUSH program.

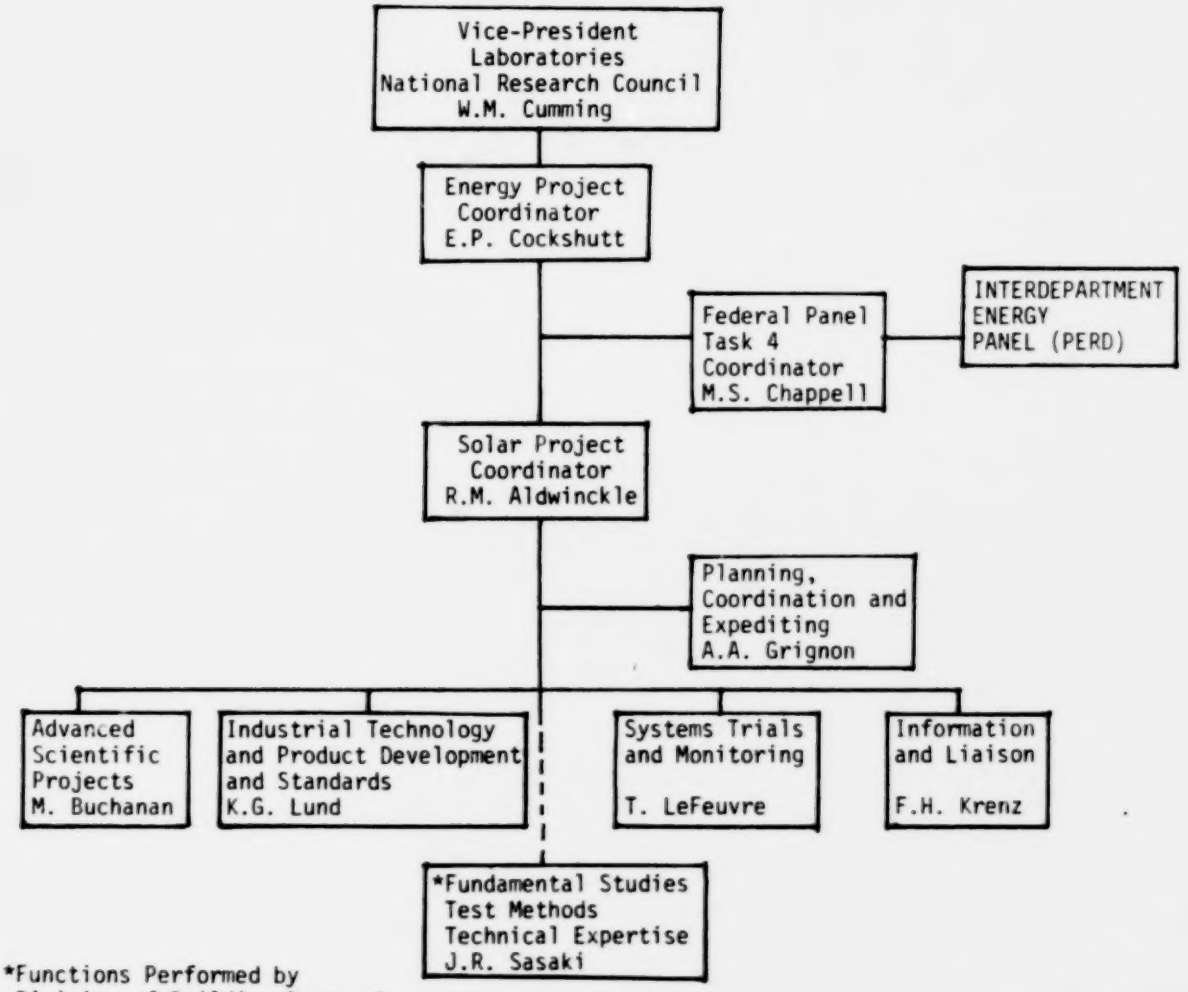
7. CONCLUSION

Canada is committed to a R & D Program to develop solar heating as a substitute for fossil fuel and to programs to create a market and to stimulate the industry.

Further information can be obtained by writing to:

Solar Energy Project
National Research Council
Ottawa, Canada K1A OR6

FIG. 1 ORGANIGRAM OF SOLAR R & D PROGRAM



*Functions Performed by
Division of Building Research
National Research Council

SOLAR ENERGY R&D PROJECTS IN DENMARK

Vagn Korsgaard and Torben V. Esbensen
Thermal Insulation Laboratory
Technical University of Denmark
Building 118, DK-2800 Lyngby

INTRODUCTION

Most of the Danish research relating to solar energy takes place at the Technical University of Denmark and the Institute of Technology in Copenhagen. The projects are financed by the Technical University, the Ministry of Commerce, and the European Community (EC). The budget for a five-year period (years not specified) includes 20 million Dcrs* for solar heating R&D and 7 million Dcrs for a low-energy housing project.

DANISH ENERGY POLICY AND SOLAR ENERGY

The energy policy statement of the Ministry of Trade and Industry "Dansk Energipolitik 1976" (Danish Energy Policy 1976) projects the breakdown of Danish energy sources and uses for 1985 and 1995. For 1995 the figures are:

Energy Source (million tons of oil equivalent)	
Coal	2.4
Oil	11.9
Natural gas	4.0
Uranium	5.7
Sun, wind, biomass & urban waste, etc.	1.0(0.5 is sun)
	25.0
Energy Use (million tons of oil equivalent)	
Electricity production	8.2
Space heating, etc.	7.4(0.5 is sun)
Industrial processes	4.0
Transportation	5.4
	25.0

The table shows a solar energy contribution of about 6% of space heating. This can be achieved by the use of 100,000 combined solar and heat pump systems and 200,000 ordinary solar heating systems. The installation of 300,000 such systems would convert a significant fraction of the 2 million dwellings in Denmark to solar energy.

*1 Dcr = US $ .1915 (on September 12, 1979)

Unfortunately, only 1000 solar heating systems are functioning today in Denmark. Clearly, an effective research and development effort, more cost-effective systems, and economic incentives are necessary to allow solar energy to make a major contribution to our energy supply by the year 2000.

THE SOLAR HEATING PROGRAM OF THE MINISTRY OF TRADE AND INDUSTRY

The program was designed to demonstrate the potential of solar energy by constructing full-scale solar systems in as many different user environments as possible. The program has also encouraged the active co-operation of the solar industry. The program has consisted of 18 tasks in the following areas:

- Demonstration projects
- Urban design analysis
- Support of component and system development
- Pilot Test Facility (PTF)
- Systems with air heating solar collectors
- Design competitions
- Solar heat for district heating
- Solar heating systems operation
- Accelerated testing of solar collectors
- Attic collectors
- Construction and field testing of solar heating systems

EXAMPLES OF RESEARCH PROJECTS IN PROGRESS

The Low-Energy House Project

The Thermal Insulation Laboratory is conducting a low-energy house project sponsored by the Danish Ministry of Commerce. Six groups of private firms are involved in this project. Each group funds the construction of its own low-energy house at Hjortekner. These dwellings are one-family houses with a living area of 120m^2 and a maximum energy consumption of 5000 kWh/year for space heating and domestic hot water. They make use of heat from the earth, solar heat gain through windows and solar collectors, as well as extra thermal insulation, airtight construction and forced ventilation and heat recovery from the exhaust air to lower consumption of commercial energy. The Thermal Insulation Laboratory will make continuous detailed energy measurements with simulated habitation of each house over one year, in order to determine its actual energy

consumption.

Solar Pilot Test Facility

Eight similar test facilities for solar heating systems have been established in the member countries of the European Community. Each facility has the possibility of testing two solar heating systems simultaneously, with a total collector area of 50 m^2 and a full back-up system. The measured results of the test program will be used to optimize component and system design.

Heat Storages with Salt Hydrates

The aim of the project is to examine and develop small heat storage units that use salt hydrates as the storage medium. Such methods require half the volume of water storage tanks. The major problem that inhibits the use of salt hydrates is their instability; the "extra-water principle" is one method that uses a water mixture to achieve stability over long periods of time.

Seasonal Storage

The objective of this project is to investigate the possibility of using a large water storage tank, whose ground sides are not insulated, for seasonal storage. A tank with a capacity of 20,000 m^3 of water is adequate for year-round storage. The top cover may be insulated in such a way that it can work as a solar collector (floating solar collector).

Design Competition

The placement of solar collectors in many existing systems may not be ideal from an esthetic point of view. To remedy this, a design competition has been initiated to offer architects the opportunity to effectively integrate solar heating systems in new and existing buildings.

Solar Heating/District Heating

A series of institutional problems inhibit the use of individual solar heating systems in districts with pipelined energy. This program analyzes a possible solution which involves the direct connection of a major, centrally situated solar heating system to the district heating station.

Loft Collectors

Cheap collectors integrated in the attic may solve the problem of achieving the optimum balance between price and efficiency. A pilot test facility has been built for full scale experiments to examine different designs of these solar collectors.

REFERENCES

Presentations of the Thermal Insulation Laboratory of the Technical University of Denmark, 1959-1979 (available from the authors).

FRENCH PROGRAMS FOR RESEARCH AND DEVELOPMENT OF SOLAR ENERGY FOR BUILDINGS

M. Bellanger
Commissariat a l'Energie Solaire
208, rue Raymond Losserand
75 014 - PARIS

M. Rodot
Centre National de la Recherche Scientifique
15, quai Anatole - France
75 007 - PARIS

J. P. Marie
Plan Construction
Ministere de l'Equipement
2 bis, avenue du Parc de Pass
75 016 - PARIS

ABSTRACT

This paper summarizes the current French program of solar energy R&D for heating and cooling of buildings.

1 - GENERAL DESCRIPTION

Solar water heaters are commercially available in France; 50,000m^2 are now produced annually. Hundreds of solar houses of several types have been built as a result of the demonstration programs of the Ministries of Industry and Technology and private initiatives.

The national goal is to replace 5.3 million tons of oil equivalent by solar heating by the year 2000. This would represent 2 to 3% of the country's total energy consumption, accomplished by 5 million solar water heaters and 1.5 million solar-heated houses. This estimate does not include possible gains from heliogeothermal systems in towns and passive systems.

Since March 1978, COMES has been given the responsibility as leader of the whole French program in solar energy. Its president, Prof. H. Durand, has estimated that the total funds devoted to the development of solar heating in France amounts to 69 MF (million francs)* in 1979. COMES is the manager of different incentives which have been set up to promote solar energy in buildings: subsidies of 1000F to private buyers of water heaters, subsidies of 50% of the cost to administrations who use solar heating in their new buildings. COMES is also continuing a demonstration program, which will be described below, and supervising the R&D activities.

The R&D activities include several programs on solar heating and a limited activity on solar cooling. The CNRS program is now concentrating on two main goals: passive systems and storage. Three programs have been launched in 1978-79 by "Plan-Construction," on:
- Climate, architecture and urban forms
- Solar technologies for houses
- Experimental passive houses

Furthermore, the CSTB (Centre Scientifique et Technique du Batiment) has increased its activity in solar heating. All these activities will be described below in more detail.

Finally, some industrial companies have developed their own R&D activities. Besides EDF (Electricité de France), St. Gobain (solar heating) and Compagnie Française des Petroles (absorption cooling), already mentioned in previous reports, the CGE(Compagnie Generale d'Electricité) has initiated in 1978 a development program centered on the simultaneous use of greenhouses and heat pumps.

2 - THE C.N.R.S. RESEARCH PROGRAM

Ten new contracts have been awarded in 1978. Among the most important actions which are being conducted the following can be listed:
- Latent heat storage in hydrated salts* (M. Schneider, Nice)
- Latent heat storage by paraffin (Mlle. Benard, Orsay in cooperation with CGE)
- Study of air heated systems with large storage (M. Chounet, Orsay)
- Numerical study of heat storage in an aquifer (M. Vachaud, Grenoble)
- Modeling and instrumentation of the solar building of Bourgoin, built by Plan Construction and Union des HLM (M. Kuhn, Grenoble)
- Solar greenhouses (three teams in Poitiers, Avignon, Nice)
- Three generation of Trombe houses (M. Robert, Odeillo)
- Refrigeration by adsorption using zeolites (M. Meunier, Orsay in collaboration with CEA and CETIAT)

In addition, in 1979 CNRS issued a book that describes recent works on the problem of statistical interpretations of meteorological data: "Analyse statistique des processus météorologiques appliquée a l'énergie solaire," published by CNRS in 1979.

*Similar research is conducted at Ecole des Mines de Paris, in Valbonne near Nice.

*1.00 FF = US $.23 (on 1 Aug. 1979)

3 - THE "PLAN-CONSTRUCTION" R&D PROGRAM

This program includes 5 kinds of activities:

3.1 - Simulation methods and modeling for architecture design

The general goal of the program is to build detailed models of the thermal behavior of a house and then to simplify these models to ease their use by architects. Among the models which exist and are being improved are those of EDF, of COSTIC, of MM. Botta and Gery (INSA-Lyon), and of M. Cordier (Toulouse) - the latter originating from the TRNSYS model of Duffie and Beckman. One project (M. Chounet) aims to adapt the DOE 1 program to France.

Another project (M. Gicguel at the Ecole des Mines) aims to define a method for climatic architectural design ass. ted by minicomputers. Simultaneously, a project (M. Kuhn) aims to validate some of these models by comparing their predictions with experimental results gathered from the Bourgoin-Jallieu house. This allows large variations in the parameters of the active solar heating system (collector area and inertia, primary exchange, use of heat pumps, storage volume, use of water or eutectic storage). It is believed that accurate models will be ready for use by architects in a few years.

3.2 - Experimental thermal studies

A large number of studies on thermal systems is underway, either by laboratories of thermokinetics or by multidisciplinary teams of architects and heat transfer experts.

One of the most common subjects is air heating. A conversion study team, led by M. Mouton (Nantes), has studied how solar radiation is intercepted by a closed channel and a ventilated channel formed by three sheets of glass. Some of the possible configurations allow the collection and transfer of more than 40% of the solar flux impinging the window. Other types of collection systems include Trombe walls with night insulation; a double glazed greenhouse in which a colored solution is injected between the layers of glass built by the INRA (Institute National de la Recherche Agronomique); and a collector in which one or two metallized polyester films can be inserted, inside a double glazing, allowing a variation of the conductivity by a factor of y, built by IRBA G.P.

The study of isolating volumes (north walls) or collecting volumes has been undertaken by several architects: M.M. Olivet and Hamayon have studied multi-family buildings with ventilated double glazing; M. Gerber has studied retrofit of greenhouses and Trombe walls. Some of these systems can be thermally regulated. Control systems using daily storage in $Ca\ Cl_2$ are being studied by M. M. Schneider and Petitcollot; those using heat pumps and condensing excess water vapor in plant-growing greenhouses, by M.M. Caignault and Le Chapellier.

3.3 - Long-term storage

A number of different methods for seasonal or long-term storage are being studied. In a project undertaken by the Commisariat a l'Energie Atomique, Gras de France and M. M. Liebard and Alexandroff, underground water tanks for storage are being constructed for 20 houses. Other projects explore in-ground heat storage with multitubular or plate exchangers. Seasonal storage systems can be augmented by the use of other energy sources: in one project, the direct conversion by hydraulic brakes of wind energy to heat is being studied for this purpose.
At the village or town district scale, the only effective solution is expected to be provided by the use of aquifers. "Plan Construction" has initiated 3 studies on the subject: a general study by Ecole des Mines and EDF; a study of the potential of surface aquifers by the BRGM (Bureau des recherches géologiques et Minieres); and modeling of storage in surface aquifers by the Laboratoire de génie civil at the University at Montpellier. The second phase of research on seasonal storage is now being planned.

3.4 - Urban design ("climatic urbanism")

Urban design is an essential element of any energy program. Urban areas should be designed in an attempt to maximize the contribution of solar energy to the city's needs. Work in this field was begun by a study to characterize urban microclimates (Mme. Miller-Chargar at Strasbourg), and continued in studies that address the legal and financial aspects of solar energy use in urban areas.

3.5 - "Plan-Construction" Research Projects

In 1978, six projects were completed under this program:

- A set of 10 single-family houses (designed by M. Liebardt and described in a paper given at the April 1978 CCMS/ISES Conference at Düsseldorf) were erected at Blagrac, near Toulouse.
- Two-hundred and thirty-five flats, in apartment buildings designed by MM. Olivet and Hamayon, were built at Beauvais.
- Six individual houses were equipped by the Solefil Company with solar systems at Trèbes.
- A 32-flat apartment building designed at the Ecole Superieur des Ingénieurs de Marseille was completed at Rousset, near Aix-en-Provence.

- Apartment buildings (40 flats) each designed by SGTE were completed at Carcasonne.

- In addition, the instrumented house (mentioned in (2) above) was completed at Bourgoin-Jallieu.

4 - THE WORK OF THE C.S.T.B (CENTRE SCIENTIFIQUE ET TECHNIQUE DE BATIMENT)

This agency, part of the Ministry of Technology, is responsible for testing, validation and certification of manufactured solar collectors. In addition, it is engaged in projects on development of solar water-heating systems, calculation of heat gain through walls and windows, and provision of thermal comfort in summer for houses located in noisy areas.

5 - THE COMES DEMONSTRATION PROGRAM

Table 1 summarizes the 67 completed demonstration projects:

Table 1. Demonstration Projects

Type of building		Number of Projects	Collector Surface (m^2)	Energy saved (t.o.e.)*	Cost of Solar System	Public Funding
Residential	Flats	10	4 090	620	5.5 MF	1.3 MF
	Indiv. houses	5	1 730	45	2.9 MF	0.8 MF
	Administration	11	1 730	320	2.9 MF	2.0 MF
	Education	12	4 430	340	5.4 MF	4.0 MF
	Swimming pools	6	1 520	120	1.8 MF	1.0 MF
	Other sports, camping, ...	6	1 660	340	1.8 MF	0.8 MF
	Socio-cultural establishments	9	650	210	1.1 MF	0.6 MF
	Commerce	1		13	0.12 MF	0.03 MF
	Health	7	1 740	200	2.45 MF	1.9 MF
Industrial sector	Textile	2	230	48		0.3 MF

*tons of oil equivalent

The entire demonstration program, including projects under way but not completed, involves 20,000m^2 of installed collectors. In order to better respond to the needs of the solar energy program, the goals of the demonstration program are being transformed. New goals include the acceleration of the collector industry, and the development of passive systems, air-heating systems and year-round storage.

SOLAR ENERGY PROJECTS FOR HEATING OF BUILDINGS IN GERMANY

F. J. Friedrich
Projektleitung Energieforschung
KFA-Jülich
Postfach 1913
D-5170 Jülich

INTRODUCTION

Research and development work devoted to the utilization of solar energy constitutes an important part of the Federal Government's overall program of research and development of new energy technologies. A comprehensive description of the program can be found in the Solar Energy Technologies Programme 1977-1980 (1). These activities are part of the Energy Research and Energy Technologies Programme 1974-1977. Detailed information on the large number of R&D Projects can be obtained from (2).

The Projektleitung Energieforschung (Project Management for Non-Nuclear Energies) is responsible for the administrative processing of the projects on behalf of the Ministry for Research and Technology.

Germany's energy requirement is characterized by a very high percentage of thermal energy. Forty percent of the aggregate primary energy requirement is for space heating. The distribution of the end-use energy requirement averaged over all sectors of consumption is (in round numbers):

- 40% space heating
- 36% process heating
- 24% light and power, (of which three quarters goes to transport)

The priorities established in research and development projects are based on this distribution. For this reason, technologies for the efficient supply of low temperature heat (below 100° C) by district heating, heat pumps and the thermal utilization of solar energy are given funding priority. In the years 1974-1978 funds totalling approximately DM 90 million* were allocated for the implementation of 95 solar energy projects. Some of these projects have already been completed; a large number of new projects are still in the planning stage. Governmental funds of DM 300 million have been allocated for solar energy R&D for the period from 1979 to 1982. Joint ventures within the framework of international cooperation supplement the research program and enable a highly efficient utilization of available funds.

According to an agreement with the CCMS Solar Energy Pilot Study Director, the following report contains only information on the changes in the German Solar Energy Program during the period since April 1978. Detailed information on all Solar Energy R&D-Projects an be found in (3).

STATUS OF PROGRAM

Production

Industry has been involved from the beginning of the program, and today there are at least 100 firms manufacturing and selling solar hot water equipment. Although there is no precise statistical material available on the number of residential systems in operation or under construction, it can be assumed that several thousand systems of this type have been installed. An attempt to arrive at accurate figures has been undertaken by the German Solar Industries Association (BSE) which sent questionnaires to German manufacturers. The responses have been evaluated by an independent expert. This canvassing will be repeated every 6 months to provide information on the rate of production and sales. The following results have been obtained:

Solar collector production (flat-plate)
Total from 1974 to June, 1978
33,000 m^2
from July 1978 to Dec., 1978
17,000 m^2

It is interesting to note the recent sharp rise in production figures. A few months ago one firm opened a production line with a capacity of 100,000m^2 per year. Another large firm is ready for a similar production increase as soon as market needs are established. A third firm has installed a production line for the manufacture of 600 m^2 of parabolic trough

*1 DM = US $0.55 (August 1, 1979)

collectors per month.

Research and Development

Current R&D activities subsidized by the Federal Government can be summarized as follows:

Activity	No. of Projects
System studies and meteorological measurements:	10
Solar thermal conversion:	
Solar houses and demonstration projects with data evaluation,	
number of installations:	72
complete systems:	3
components:	17
agricultural applications:	3
Solar mechanical conversion for electricity generation and water pumping:	7
Photovoltaic conversion:	10

The focal point of the program has been, and still tends to be, low temperature thermal applications. This topic will be described below in more detail.

There is increased activity in the field of solar mechanical energy conversion for water pumping and electricity generation. Germany has joined the group of countries in the European Community and in the International Energy Agency that is financing powerstations in the half megawatt and megawatt range. A feasibility study for a 20 MW gas turbine power station has been initiated. In the short and medium term, application of these technologies certainly lies outside Europe. The same is true of photovoltaic energy conversion which has been increasingly supported in the past year. Investigation into photochemical and photobiological conversion processes is being carried out at the university level; these processes are considered as long range options.

Some essential developments and project trends of the last year are reviewed below. For more detailed information on the projects, see (3).

System Studies

Of the various activities being undertaken, the studies investigating "Obstacles to the Introduction of Solar Systems" and "Solar Architecture" have been completed. One essential barrier to the operating of the solar market is obviously the high price of the systems. But even if this obstacle is removed by the increase in fossil fuel costs, a maximum of only 35% of all buildings are appropriate for the installation of solar systems. In this context "appropriate" has been defined as:

roof angle tilt of: 30 to 70 degrees
roof orientation : south ± 30 degrees
roof essentially unshaded

Flat roofs are not considered appropriate since rows of tilted collectors would spoil the shape of the flat roof prescribed by urban planning authorities. Assuming that future urban planning considers solar energy requirements, some 70-80% of buildings could be equipped with solar systems.

Meteorological Measurements

Sound cooperation between meteorologists and solar energy scientists has finally been established, not only on a national basis but also throughout the European Community. Moreover, in a cooperative project of the International Energy Agency new solar radiation measurement packages have been developed by the USA, Switzerland and Germany. Their performance and accuracy was compared last September at the Hamburg Meteorological Observatory. In a new project, the software is being developed for computerized evaluation of satellite weather pictures that reveal insolation on the ground. It is expected that the resolution and the accuracy of this process will permit solar system evaluation in all regions of the world. This is of special importance for regions lacking a meteorological network of sufficient density.

Solar Houses

The first and most important of the solar house projects, the Philips Zero Energy House in Aachen, has been completed. In this project various types of evacuated tubular collectors were developed and tested. The house has been equipped with high grade wall insolation and a large thermal storage system for winter heating. In addition, the waste heat from various household appliances is collected, stored and fed back to the heating system via a heat pump. The group of scientists engaged in the project made an essential contribution to the understanding of solar system behavior. Test programs and experimental results were exchanged with the USA and Denmark, where similar houses had been in operation.

Another example of successful international cooperation is the planning of the Freiburg Solar House, which was inaugurated last autumn. A similar house has been built by the Colorado State University. One special feature of the cooperative project is that both houses have been equipped with tubular evacuated collectors of German as well as of US production. The project is expected to yield extremely interesting results due to equipment identity on the one hand and remarkable climatic differences on the other.

In the National Program for Future Investment

(ZIP), 80 solar energy systems have been installed on government-owned buildings. Twenty-five of these are equipped with data collection systems.

The planning phase for an even larger project is nearly completed. It will comprise some 500 to 1000 houses distributed throughout the country and equipped with various brands of solar systems. The selection of the brand is deliberately uncoordinated and left to the house owner, in order to simulate realistic conditions. It will essentially be a trouble-finding project: in the first step typical mistakes made during plumbing and installation will be detected. Later all information on system failures and aging properties will be evacuated and fed back to manufacturers, constructors and plumbers. In this way, the learning period for all groups engaged in solar heating systems will be shortened. All systems will be equipped with data collection systems, transmitting their output to a central computer over a period of at least five years. Successful handling of the project is anticipated to be extremely complicated and extensive planning is required to provide the basis for the final decision.

An architect's competition for the planning of a residential area near Landstuhl is being prepared. The project will comprise 50 houses of 3 or 4 types equipped with solar collectors, solar assisted heat pumps or conventional heat pumps. Moreover, new ideas for passive systems will be incorporated. The estimated cost of the project is DM 8 million.

Swimming Pool Heating

The heating of swimming pools is considered to be almost economical. A final series of 10 public outdoor and 6 public indoor swimming pools will be supported for demonstration purposes. They will be equipped with surface covering systems and heat pumps. The planning of the project is nearly completed.

Components

The development of solar assisted heat pump systems which utilize the total area (south and north) of the roofs as air-to-liquid heat exchangers has been emphasized during the last year. Non-insulated solar absorbers are fitted instead of roofing tiles. For the mild and rainy winter climate of northwest Germany energy savings per year have been computed to be as much as 2.5 times higher than with standard solar collectors. In one project the following 4 systems are being compared: standard solar collectors, black coated; standard solar collectors, selective; absorbing-roof, black coated; and absorbing-roof with selective coating.

One project using horizontally mounted collectors has been completed. Vertically mounted facade collectors are being installed on a university building in Berlin. One essential side effect is the resulting improvement in wall insulation.

Two firms have developed flat-plate vacuum-tube collectors with excellent thermal properties. Application is envisaged for cooling systems and process heat applications.

Thermal Energy Storage

This aspect of R&D has not yet yielded important results. Various small latent-heat storage projects are in progress. However, the technical and economical feasibility of the new concepts is still unknown.

The planning of a large thermal storage system (75 m x 51 m x 13 m) is nearly completed and excavation work will begin this year in Mannheim. The pool will be heated with waste heat from a power station and the heat distributed into the district heating network. The project will be partly financed by some member countries of the International Energy Agency.

Solar Cooling

An analysis has revealed that a national market for solar cooling systems cannot be expected in the short or medium term. A few projects have been started in this field in cooperation with tropical countries. Cold storage with an absorption chiller has been set up in Cairo, Egypt; and space cooling systems are being prepared in cooperation with Iran and Mexico, where the planning phase for a "solar village" is nearly completed. One firm is developing an ammonia-water chiller to be used in conjunction with parabolic trough collectors.

SUPPORT ACTIONS

Basic and Applied Research

Support for basic research in the field of hot water and space heating systems has been kept constant, although the total program has been remarkably expanded. However, basic research in photovoltaics, thermal power stations and photobiology has been expanded. On the other hand, technical universities and engineering schools have been more frequently involved in carrying out measuring programs for industrial and demonstration projects. In this way the new generation of scientists will obtain practical experience with solar energy utilization.

Basic research in the field of solar heating and cooling is focused on the following sectors:

- Selective coatings. Although the stability of these layers on aluminum has been improved, a satisfactory long term stability has not yet been achieved.

- Solar cooling. A basic research program has been started with the aim of finding new substances for absorption systems working at lower input temperatures.

- Thermal storage. Chemical energy storage has received increased attention during the last year. Although some of the proposals seem to be technically feasible, the question of their economical applicability is still open.

Fiscal Support

Economical conditions for the installation of solar systems have been improved by the following fiscal incentives and programs:

- an income tax reduction for owners of private houses

- a tax reduction for new solar-assisted heating systems that replace unserviceable old heating systems

- a 7.5% investment benefit (synchronized with national investment program)

- a DM 30 million program for installation of solar systems in government-owned buildings (1978-1980)

- a DM 4.35 billion investment program for the installation of energy saving devices (i.e. improved wall insulation, double windows, heat pumps, and solar systems).

Quality Standards

System Safety

System safety is being considered by joint groups of experts from the Solar Industries Association (BSE), the German Engineers Association (VDI) and the German Industrial Standard Committee (DIN). A first draft of regulations has been written and is being discussed by all interested parties. Although early introduction of the new regulations would enhance consumer protection, it could also restrict the free development of the technology.

Collector Testing

Since the collector is the key component of a solar system, its thermal properties and its durability should be precisely determined and the information made available to the customer. Standardized testing methods are being developed nationally and within the framework of the International Energy Agency. Progress has been made in establishing methods for measuring thermal characteristics. A reliable determination of durability properties has proved to be more difficult.

The organizational structure for collector tests is now complete. Testing methods were developed by scientists from governmental and industrial laboratories; the actual testing will be performed by the Technical Control Board (TÜV). TÜV will:

- test prototype collectors for industry and issue quality certificates;

- test collectors that are already on the market for the Consumers Association (Warentest Institut), which will publish the results in its monthly periodical.

This process is expected to lead to a gradual improvement in component quality.

CONCLUSION

The expected broad market for solar systems has not yet been established. By further expanding its solar energy program, the government is assisting industry and builders in their preparations for that event. Basic research activities in the field of solar heating may be slightly reduced in favor of various steps to ensure the necessary high quality and durability of components and systems.

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(2) Annual Report 1978 on Efficient Uses of Energy, Fossil Sources of Primary Energy and New Sources of Energy (in English), Press Department, Federal Ministry for Research and Technology, D-5300, Bonn, Germany.

(3) Annual Report 1978 on New Sources of Energy, Section Solar Energy. Source: see (2).

GREEK SOLAR HEATING AND COOLING PROGRAM

E. Delyannis, R. Belesiotis, and A. Delyannis
Greek Atomic Energy Commission
Nuclear Research Center "Demokritus"
Aghia Paraskevi
Attika

Solar heating and cooling activities in Greece include the following elements: a completed demonstration project at the "Democritos" Research Center, other planned demonstrations, participation in a joint project with the US for community planning, and some privately built solar houses.

DEMONSTRATION PROJECTS

A reflecting, horizontal solar collector, that contains absorbing surfaces and reflectors under a glass cover, was developed at the "Democritos" Research Center. The effects of reflector use and of the angle of inclination have been measured. Ninety-six such collectors (area 168m^2) have been installed on a system in the "Democritos" administration building with a 7m^3 storage tank and auxiliary oil heating. No performance measurements have yet been made; however preliminary results indicate that the storage capacity is inadequate. In the second phase of the project, the possibility of solar cooling of the building will be explored.

URBAN PLANNING

In October 1976, an agreement was signed between the U.S. ERDA and the Greek National Energy Council for a community planning project. The project involves a study of special energy systems in community planning. The study devised 2 community designs and recommended the use of solar thermal electric energy and biomass, as well as of direct solar energy. Frangocastello, in the southern part of Crete, has been chosen as the site for the prototype community, further study of which is being undertaken by the National Energy Council of Greece. Other planned demonstration projects include heating of a school building and a government-built apartment building.

PRIVATELY BUILT HOUSES

Several houses that use water-heating solar collectors have been built in Greece. One house, built by the architect, Mr. A. Tombazis, has a floor area of 96m^2 heated by 25m^2 of collectors with an 8m^3 storage tank. The heated water is circulated in plastic pipes under the floor. The system relies on auxiliary electric heating.

REPORT ON ACTIVITIES IN ISRAEL ON SOLAR HEATING AND COOLING OF BUILDINGS

Harry Tabor
Scientific Research Foundation
Jerusalem

INTRODUCTION

Despite the widespread use of solar energy for water heating in Israel, it is little used for heating and cooling of buildings; the reasons are climatic and sociological. In most of the country, the winter period is short - of the order of three to four months - so that an expensive solar installation for heating only is generally difficult to justify on economic grounds. (For the same reason many dwellings do not have central heating systems and rely on electric or kerosene heaters to deal with the short cold spells. In areas where the winter is longer, central heating is more widespread). If the solar collector system were also used to provide cooling, the collector system would have a greater utilization factor, thereby improving its economic viability. However, domestic air-conditioning is relatively rare in the present state of economic development. Thus there is relatively little demand for air-conditioning.

Although total activity in active solar heating and cooling of buildings is relatively small, there is much work underway on passive systems or on components that could be used in active solar heating and cooling systems. Almost all the work described below receives partial support from the Ministry of Energy and Infrastructure or, in the case of components, from the Ministry of Trade, Commerce, and Industry.

PASSIVE SYSTEMS

The major passive program is supervised by Prof. Givoni at the Ben Gurion University (Sde Boker campus).

Building Design in Relation to Climate

The work in this area involves the development of guidelines for building design and construction aimed at providing comfortable indoor climatic conditions while minimizing the energy requirements of the building. The guidelines are based on extensive basic research on the effects on the indoor climate and comfort conditions of various design factors, including

- orientation of windows and walls;
- shading conditions of windows
- external color of walls (under different conditions of various materials' properties);
- size and location of windows;
- indoor ventilation conditions; and
- thermal resistance and heat capacity of walls and roofs.

Solar Heating of Buildings

Research in this area is directed towards the development of integrated systems for solar heating of buildings. The term "integrated" means that various architectural and structural elements of the building serve as integral components of the energy system. Several different systems are being developed. In these systems, various building elements, such as southern windows (direct gain), southern walls (either heavy or lightweight), and the roof serve as solar collectors. The capacity of the structural mass to serve as thermal storage is being investigated. In addition, a basic study of the performance of thermal storage in pebble-beds is being conducted. It concentrates mainly on the effects that various design features and pebble size have on airflow resistance. The different systems under development are meant for different climatic conditions ranging from cold climates to hot deserts and for different building types, ranging from low- to high-rise buildings and from single family houses to apartment blocks. One of the main problems addressed by these studies is indoor temperature fluctuations, which are characteristic of passive systems. Different ways of keeping these fluctuations within a range acceptable to human comfort are being studied.

Natural Cooling of Buildings

Research in this area focuses on nighttime cooling of buildings in summer. The following passive cooling methods are being studied:

- nocturnal long wavelength radiation;
- cool night air ventilation;
- direct nocturnal evaporative cooling of pebble-bed storage.

All these systems store night cold in the mass of the structure of the building and/or in a specialized pebble-bed. The cooled mass is used during the following day to absorb the heat penetrating into the building so as to keep the temperature rise within limits acceptable for comfort.

Design of solar houses

Different prototype buildings that are heated and cooled year-round by solar energy are being designed. One such prototype will shortly be built at the Institute of Desert Research.

Other Passive Research

At the Technion (Haifa) Department of Building Research, somewhat similar work is going on under the supervision of Dr. Mil Hoffman. The work concerns thermal network analysis techniques.

A current project supervised by T. Schwartz at the RASSOL Co., of Tel Aviv, is concerned with energy-saving improvements in the construction of dwellings. The improvements relate to insulation and density of walls, roofs and floors; size and shape of fenestration; window shading to prevent direct gain in summer; and prevention of air infiltration. A computer simulation program developed at the Tel-Aviv University has been used to calculate the economics of each of the above parameters and its contribution to possible energy saving. This program provides optimization and cost effectiveness of the various parameters, and estimates the yearly energy savings resulting from the improvement. The simulation evaluates the contribution of all parameters by performing transient energy analysis. Data is collected from two apartment buildings of 12 apartments each built by Rassco in Ra'anana. The two buildings are identical, except that the second one is being built with all improvements as derived from the simulation. All rooms in both buildings are being equipped with temperature, humidity, electricity and gas consumption sensors. This information will be recorded on magnetic tape along with other climatic data and processed by computer. The computer will perform calculations and comparisons between the two buildings and will provide the following information:

a) Yearly energy savings achieved by the second building, as compared to the first building, under real living conditions.
b) The technical efficiency and economic viability of the improvements.
c) Improvement in comfort conditions achieved by the modified construction without mechanical heating or cooling.
d) Verification of the simulation program and preparation of recommendations regarding improvements in future construction.

The entire project will cover three years, with a minimum of one year of simultaneous data acquisition in both buildings.

ACTIVE SYSTEMS

This section describes experimental buildings and component or system studies.

Buildings

(1) The "Integrated Solar Roof" - MIROMIT CO.

Some three years ago the MIROMIT company decided to develop a large solar collector which was also the roof constructional element. The roof system has been developed in cooperation with the Department of Building Technology of the Technion in Haifa, and with support from the Ministry of Commerce and Industry. A typical pre-fabricated light-weight concrete element is 7.20m^2 (24 ft.) by 120m (4 ft.) wide with a depth of 30 cm to provide the necessary rigidity. The total weight, including glass and absorber plate, is 1590 kg. Prototypes were fabricated and tested at the Technion and then TRANSYS computer simulation program run through for several typical family houses.

Three houses using these integrated collectors have been designed and as of Jan. 1979, one (the Gruber house) was completed and occupied. The other two will be completed during 1979. The collectors are air-heaters and are used together with a rockpile. The building is heated from air-ducts. Full operational data is not yet available, but computer programs based on real collector efficiencies and local climatological data have allowed viability to be determined. For a large dwelling. of several hundred square metres floor area, the installed cost of the collector system, including rock-bed storage and controls is of the order of 180/m^2. If one deducts the cost of the roof that the system replaces, (including the insulation and the horizontal ceiling which are not needed in the present design), one can subtract almost a third of the cost. Even in the mild Israeli climate, the units should prove viable for large houses; in the regions with a longer winter the system is expected to be viable even for small dwellings of 100m^2 floor area.

(2) SOLIT LTD. is experimenting with a system in which a solar air heating system replaces part of the tiled roof; thermal storage is in the mass of the building. Particular care is taken to reduce heat loss by good insulation of walls and roof. One home has been built using this system.

(3) TECHNION, Haifa, Department of Mechanical Engineering. A 120m^2 library has been fitted with 90m^2 of liquid flat-plate collec-

tors to provide winter heating. Ten m^3 of water provide heat storage. The building is heated by means of fan-coil units. Full monitoring of the building should be completed by next winter. Due to the relatively short heating season (3-4 months), it does not appear that this is an economically viable installation; it was used primarily for learning purposes.

(4) BEN GURION UNIVERSITY. A plan has been prepared to heat a $100m^2$ building on the campus, using $60m^2$ of flat-plate air collectors. Collectors would also be used for convective cooling at night in summer. The project has not been executed due to lack of funding.

Components

(1) Improved Absorption Coolers. During the past year the ASD (applied solar devices) program of the TADIRAN company focused on the operation of the 50 ton prototype solar air-conditioning system located in its development facility in Tel Aviv. The company also began to operate other systems in Israel and abroad. Achievements of the program include:

- o Initiation of mass production of all copper flat plate solar collectors with a proprietary selective surface. The process includes an automated line operation in a full-scale industrial plating facility.
- o Design of systems for central hot water, space heating and total climate control with chilling capacities of up to 200 tons and collector arrays of $4000m^2$.
- o Purchase and installation of most of the manufacturing equipment necessary for domestic manufacturing of solar powered absorption chillers in Israel.

(2) Low Temperature Ejectors for cooling (0.5 ton capacity) are the subject of experiments using waste heat, that are underway at AGRAN CO. Because of the low operating temperature, such ejectors could also be suitable for solar cooling, but only if the calories were very low in cost because of the low efficiency of ejector systems.

(3) Solar Assisted Heat Pump. Work in this area is being carried out by the ELECTRA company, the pumps are primarily for office buildings. One of the company's offices has been equipped with one SAHP system using $10m^2$ of solar collectors. Winter heating has shown COP's of the system, including the heat pump, of 3.2 - 4.3. On summer nights, heat is rejected from a cooling tower and the solar collectors. The company is now installing a larger unit for heating and cooling (to be operating by August 1979) that provides 5 tons of cooling in summer and uses $20m^2$ of collectors to boost the heat obtained by the heat pump for winter heating.

(4) Liquid Dessicant System. This system, using lithium bromide or triethylene glycol, is the subject of a study at the Dept. of Mechanical Engineering, at the Technion, Haifa. The study aims to reduce the relative humidity of the air by half, thus permitting evaporative cooling, and to regenerate the dessicant by using solar energy. At the present stage, the solar energy is simulated with electrical heating.

PARTIAL LIST OF COMPANIES AND INSTITUTIONS INVOLVED IN SOLAR HEATING AND COOLING OF BUILDINGS

TECHNION, Haifa	
M. Hoffman	Thermal networks
G. Grossman	Collectors, liquid dessicant system
BEN-GURION Univ.	
D. Wolf	Experimental solar heated building
B. Givoni	Passive systems
AGRAN Co., Tel-Aviv	
A. Manor	Experimental solar cooling devices
ELECTRA, Tel-Aviv	
A. Katz	Solar assisted heat pump
MIROMIT, Bnei-Brak	
G. Belkin	Solar roof (air-heating)
TADIRAN, Tel-Aviv	
J. Landau	Absorption cooling
SOLIT, Tel-Aviv	
I. Kleinberger	Air heaters

THE SOLAR HEATING AND COOLING PROGRAM IN ITALY

Roberto Visentin
P.F.E. - Consiglio Nazionale delle Ricerche
Via Morgagni 30/E
Rome

This paper presents the program of the Consiglio Nazionale delle Ricerche (CNR) for research and demonstration of solar heating and cooling of buildings and industrial process heat. It also presents data on funding by the CNR and the Ministry of Industry for the period 1976-1979.

The major objective of the Italian solar energy R & D program is the reduction of the current high consumption (20% of imported energy) for the heating of buildings. Two actions form the basis of government-sponsored energy conservation activities:

a) Government funds allocated to support CNR R & D program

b) The regulations for reduction of energy consumption for heating of buildings. (Law #373, April 30, 1976)

At present, the only active and coordinated program in solar energy utilization is the CNR R & D program, including these activities:

1) Thirty new meteorological stations will measure global and direct solar radiation, wind speed and direction, and other meteorological parameters under construction.

2) Historical weather data have been analyzed and used to devise a chart of mean insolation in Italy.

3) Computer simulations modeling the performance of solar heated buildings have been prepared.

4) Design methods for new buildings and for urban retrofit schemes have been studied.

5) New regulations encouraging the use of solar systems have been proposed.

6) Instrumentation methods to measure component and system performance have been prepared.

7) Eight multi-story buildings have been instrumented; four of these buildings use flat-plate liquid cooled collectors; one uses a small parabolic trough concentrator, one uses flat-plate air-cooled collectors, and one is an active/passive hybrid system using flat-plate liquid cooled collectors.

8) Plastic and rubber flat plate collector components are being developed.

9) Small experimental systems for agricultural applications are being constructed.

Despite favorable weather conditions, the cooling program is less extensive. This is due to the relatively few air conditioned buildings in Italy. Nevertheless, refrigeration systems are being developed for food preservation and agricultural applications. Two absorption cooling systems using ($LiBr - H_2O$ and $NH_3 - H_2O$) have been studied and two units (25,000 Frig/h) are presently under construction. They are expected to achieve cooling at temperatures between 5^0C and -20^0C, and will be tested in complete systems.

The CNR also participates in all 5 tasks of the IEA Implementing Agreement for Solar Heating and Cooling of Buildings.

Under Law #373, the government has financed energy-conserving solar buildings, of which the most representative is a 7000 m^3 laboratory under construction at the University of Calabria. The system will use a large array of flat-plate air-heating collectors and a heat pump for building heating and air conditioning. Buildings constructed under this law will be monitored and system performance data transmitted to the Ministry of Industry.

In order to prepare for the development of process heat systems, the CNR is supporting research on thermal energy consumption in food processing and textile industries.

A prototype cylindrical parabolic trough of modular length (34 m) with an aperture at 2.5 m^2 is under construction as part of the Calabria Project. It is expected to produce temperatures of from 120°C to 280°C. A 100 KW_{th} solar power plant for food-processing (peak power at 120°C to 150°C) is being designed as part of the Sicily Project. The funding levels of the CNR programs are as follows:

1) The Heating and Cooling Research Program: $US 1.2 million in FY 76-FY 78. Planned expenditure in FY 79: $US 1.1 million.

2) Components and Design of the Solar Power Plant: $US 0.45 million in 1978. Planned expenditure in FY 79: $US 0.9 million.

3) A demonstration program for the heating of buildings has been funded jointly with the Department of Industry for $US 1.6 million in FY 1978.

In conclusion, the Italian solar energy program has attempted to prepare the basis for the use of solar energy. More work needs to be done in the areas of energy conservation in buildings and industrial processes; integration of collectors into roofs and walls; and improved storage methods.

JAMAICA'S SOLAR ENERGY PROGRAMME

W. R. Ashby
Ministry of Mining and Natural Resources
Kingston

INTRODUCTION

Jamaica has been a member of the CCMS Solar Energy project since 1975. If one asks what we have to show for this activity, the answer will be, "very little." But if the same question is asked one year from now, the answer should be rather different. That is because the last three years have been devoted to administrative efforts to create the right conditions for significant progress, and these are only now beginning to bear fruit.

To have a meaningful development programme, it is necessary to have project funding and an institution able to carry out the appropriate projects. Given the difficult economic situation of the Jamaican government, it has taken a correspondingly long time to acquire each.

The Scientific Research Council, which is the country's chief technical development institute, has just acquired, at the beginning of this year, an Energy Projects Division, whose creation is the result of some years of persistent effort, and similar efforts are still being made to obtain institutional support for the College of Arts, Science and Technology, abbreviated CAST, which is a technical training college also interested in alternative energy.

SOLAR PROJECTS

Similarly, project funding has been sought mainly from technical assistance agencies, and such arrangements take rather long to be concluded. But that is not to say that nothing has been achieved; and we therefore wish to acknowledge the support of those institutions which have enabled the beginnings of an energy programme, namely the Organization of American States, the Commonwealth Science Council of London, and the United States Agency for International Development.

The OAS has funded a small photovoltaic demonstration project at CAST, and most recently, a programme of solar radiation mapping.

The Commonwealth Science Council has sponsored a regional Caribbean Alternative Energy Programme, and given logistic support to a Steering Committee which has prepared a series of projects conceived as a joint cooperative effort among the territories of the English-speaking Caribbean.

The USAID has given assistance in two ways. Through a bilateral agreement with the Government of Jamaica a series of feasibility studies will shortly be carried out, including the areas of solar and biomass applications. The other AID programme, which is still being formulated, is again a regional programme of project development and training in alternative energy; though the Caribbean region for this purpose includes Haiti and Santo Domingo as well as the English-speaking territories.

In addition to the projects so far mentioned, small scale projects have also been carried out on Jamaican Government funding in biogas, solar crop drying, and the design of a solar concentrating collector.

DOMESTIC HOT WATER

Another important development has to do with the commercialization of solar water heaters. There has long been an effort, so far unsuccessful, to secure government financial incentives to promote the marketing of solar heaters; but recently the Jamaica Public Service Co., which is the local electric utility, has announced its own programme to make loans to customers for purchasing solar water heaters, and this programme is counted upon to give a great filip to a market which has so far languished for the lack of such incentives.

CONCLUSION

The Jamaican position may therefore be summarized by saying that while so far there are no significant accomplishments to report, there has been a great deal of preparatory activity over a period of three years, which by the time this Conference meets again, should provide us with worthy attainments signifying important progress.

Institutions have been put in place, projects developed and funding sought, both in a local and a regional context. The areas of project interest include some which are not properly the subject matter of this Conference, and embraces Solar Crop-drying, Solar Cooling and refrigeration, biogas, charcoal, biomass, wind, mini-hydro systems and the development of solar water heating on a commercial and industrial scale, though the order of priority is not necessarily the order given.

We also acknowledge the assistance of those agencies who have made our programme possible.

INDUSTRIAL SOLAR ENERGY ACTIVITY IN MONACO

J. H. Millar, F.R.Ae.S.
Flextube S.A.
B.P. 147

FLEXTUBE S.A. of Monaco is developing solar energy components and systems for hotels, apartment buildings, hospitals, casinos, theatres, restaurants, government and office buildings, factories, gymnasiums, swimming pools, and sea-water desalination. Flextube S.A. has progressed from the use of low (1%) efficiency Alcoa flat plate collectors which warped and corroded in 1973, to east-west tracking image collectors with double wall straight-through vacuum insulated coated tubing with an efficiency of 70%.

Projects underway include 2 types of solar collectors and 3 types of vacuum insulated tubes, one with photovoltaic cells. The concentrators are of the non-imaging non-tracking, compound parabolic type with 3 types of vacuum insulated selective coated tubing. Advanced types of photo-voltaic cells for electricity generation are also being developed.

An apartment building of 50 apartments has been designed to use solar power to heat water for domestic use. For aesthetic reasons it was not possible to group the collectors on the roof to provide heat energy for heating and cooling. Each individual apartment will have solar collectors at an angle of 60^{0} against balconies and large flower pots and are considered as being part of the decoration of the facade.

STATUS OF THE PROGRAM

During 1977-78 the program changed in scope: aluminum flat plate collectors were abandoned. Two types of non-tracking, non-imaging compound parabolic collectors are being developed. They have advanced reflective surfaces and 3 types of selective coated, vacuum insulated "straight-through" tubes. One of the concentrators will be shaped to take solar cells which will be cooled by a fluid flowing through the tube to a heat exchanger.

PROGRAM ELEMENTS

Collectors: The program attempts to demonstrate that the non-imaging, non-tracking, compound parabolic concentrator with advanced reflective surface and a vacuum insulated selective coated absorber will produce more heat per m^2 at a lower overall cost per thermal KW than any other type of static collector having no moving parts (other than the pump rotor). When equipped with suitable heat exchangers, these collectors will occupy far less space for the same thermal KW output than other static collectors. This makes them more economical for all thermal and electro-thermal applications. For new construction, modules of static concentrators with compound parabolic reflectors equipped with vacuum tubes having the latest straight-through flow will prove the cheapest in energy produced per m^2 of space occupied. Furthermore, since they nave no mechanism for east-west tracking or north-south tilting, maintenance will be minimal.

Flextube's experiments with aluminum flat plate collectors, paints and coverings, and various kinds of chemical anti-freeze and anti-corrosion mixtures led to some problems with entrapped air, corrosion of the panels, and cloudy weather. Mass manufacture of vacuum tubes with selective coating has met the need for an improvement over flat plates. Because of their shape, compound parabolic collectors need no tracking mechanism. The receiver is a tube carrying a gas or a fluid. The tube has a selective coating and is enclosed in a vacuum (of 10-6 torr) to reduce heat losses. If the working fluid is a liquid such as water it is preferable to have a system which drains completely to avoid frost damage during cold nights in northern latitudes. If air is used as the fluid medium there is no risk of frost damage. The concentration ratio (the ratio of the diameter of the reflector apperture to the circumference of the absorber tube) ranges from 1 to 2.

To ensure a continuous vacuum in big industrial installations all the vacuum points should be connected together and through double wall vacuum insulated rigid and flexible tubing to small efficient vacuum pumps. Flextube's compound parabolic concentrators have spray bars along the top to wash the covers, and electric wipers to keep the covers clean. The compound parabolic collectors are eminently suitable for industrial process heat applications and for applications in developing countries.

Heat Exchangers: Flextube has successfully used a wire finning on the outside and inside of the tubing. The wire finning improves the heat transfer rate by increasing the turbulence of the fluid (a liquid or a gas) in the tubing. Depending on the density of the internal winding selected, the heat transfer rate can be up to 8 times better per metre of length than for plain tubes of the same bore. External loops give heat transfer rates 3 to 4 times better than plain tube. Internal looping increases the pressure drop per metre but the higher heat transfer rate allows less tubing to be used and results in a smaller heat exchange unit with an overall pressure drop within acceptable limits.

Swimming Pool Heating: Flextube has used CPC collectors with and without heat exchangers to heat swimming pools. To prevent nighttime heat loss, Flextube has installed a swimming pool cover that slides on parallel rails along each side of the pool. It is propelled back and forth by hydraulic power from the 1½ h.p. filtration pump. Although the cover can be added after the pool is built, it can more easily be built in.

CONCLUSION

The great electrical engineer Nicola Tesla (who created stationary or standing waves on the earth in the 19th Century) wrote, "There is also a possibility . . . that we may obtain electrical energy direct from the sun."

NATIONAL SOLAR HEATING & COOLING PROGRAM IN THE NETHERLANDS

K. Joon
P.F. Sens
Netherlands Energy Research Foundation
P.O. Box 1
1755 ZG Petten

W.J. van Koppen
Eindhoven University of Technology
Department of Mechanical Engineering
P.O. Box 513
5600 MB Eindhoven

INTRODUCTION

Holland is a small country on the east side of the North Sea. It is located at 52°N and 5°E, and its altitude ranges from several meters below sea level to a few dozen meters above. Because of this location the climate has predominantly south westerly winds at an average speed of 3.3 meters per second in the reference year. These winds bring humid air into the country, so that the average cloud cover is 5.5 octas, the precipitation 723mm. per year and the annual sunshine amounts to 1400 hours. The maximum ambient temperature is 26.8°C, the minimim temperature minus 11.5° C, again in the reference year. Based on a temperature of 18°C the heating degree days amount to 3644. The global insolation on a horizontal plane is 976 kWh per m^2 and year. Of this 64% is diffuse radiation.

From these data it is clear that the prospects for application of solar energy systems in the Netherlands are not too bright. In addition, the country has large domestic reserves of natural gas, which at present is still cheap. As a result, the latest projection of energy consumption by the government include a contribution from solar (See Fig. 1) of only 1-1.5% by the year 2000. Thus the incentives to carry out an advanced solar R&D program are not very large. Nevertheless, the government has decided to carry through a limited program as part of its overall energy R&D program.

ORGANIZATION

In the Netherlands energy policy is the responsibility of the Ministry of Economic Affairs. It was this Ministry which, after advice from the National Steering Committee on Energy Research, requested the Project Office for Energy Research of the Netherlands Energy Research Foundation to formulate national R&D program on solar energy on January 1, 1978. On January 1, 1979 the same office was designated to manage the program, which by then had been approved by the Minister of Economic Affairs. The program will be carried out on a contract basis where contractors include most groups involved in society, i.e. educational institutions and universities, research institutes, industry, construction companies, technical advisers, installers, housing development corporations, etc. The program comprises four phases, each with a duration of 3 to 4 years (see Fig. 2). The first phase, which ends at the end of 1981, has now been approved with a budget of about $10 million. It is expected that another $5 million will be contributed by the participants in the program, i.e. other government and local authorities, the European Communities, industry, etc. The division of the program in four phases is based on the assumption that solar domestic water heating, solar space heating, seasonal storage and solar cooling will become commercial in that order. In each phase, one of these technologies will be brought to the level of large scale technical (and hopefully economic) demonstration. The research, development and practical experimental work will be carried out during the preceding phases.

OBJECTIVES

The main objective of the Dutch national program is to encourage the introduction and broadening of the applications of solar energy in the Netherlands at minimum costs for the community. This aim will be attained by the accumulation of knowledge and data in projects that attempt to improve the performance and reliability of solar energy systems and their components, reduce costs, and create sound industrial activity and a commercial market.

Within the frame of the main objectives of the national program as a whole, specific aims for Phase I can be formulated as follows:

a. To demonstrate the applicability under Dutch conditions of solar energy systems for the production of domestic hot water for various user groups.
b. To develop policy making recommendations concerning the introduction and cost-price development of solar water heating systems.
c. To prepare and formulate a detailed program for the second phase of the national program, during which space heating will be

demonstrated.

d. To undertake exploratory and fundamental research and evaluations concerning seasonal storage and cooling in preparation for increased efforts in these areas during the second phase.
e. To evaluate and analyze the social and economic consequences of the production of solar energy in general, and in particular, to develop consumer protective measures.

SCOPE

The current first phase of the program focuses on five technologies. These are domestic hot water, space heating, seasonal storage, cooling and subjects of general interest. The funding of these subjects, not including external contributions, is shown in Table 1.

Domestic Hot Water Supply

Because the development of solar water heating is already relatively advanced, research and development projects will be outnumbered by a series of large scale demonstration projects. These results will aid in verification and improvement of earlier predictions of speed of introduction and cost/price developments. Ten research projects have been identified. The results of these projects, together with systems analysis and measured data from five well-instrumented field experiments of limited size, will provide the information necessary for optimization studies. Additional necessary construction, installation and cost/price information will be derived from five large-scale demonstration projects in each of the user sectors: new- and retrofit single family houses and apartment buildings, swimming pools, utility buildings, agriculture and industry. In another project, the performance of combined space heating and solar water heating systems will be studied.

Ten projects in the socio-economic area have been identified. These comprise development of standards, codes of practice, minimum property requirements, test procedures and studies concerning the effects of the introduction of solar water heaters on employment, productive capacity, energy supply, building codes and public and private economic activity. About US $2.5 million has been reserved for this part of the program, although it will be augmented by contributions from other sources.

Space Heating

The projects in this category will provide the input for the second phase of the national program, in which space heating will be brought to at least the level of technical demonstration. The program thus focuses more on research and development work than the solar water heating program, although some of the larger projects have a demonstration component.

Twenty-five research and development projects are underway. Some of the projects have a fundamental character, (for example, research on spectral selective materials). Others are also relevant for solar water heating systems. All projects attempt to improve the efficiency and decrease the cost of the whole system. Subjects being studied include collectors, coolants, short term storage, auxiliary heating, controls, integration of different components, and integration of the whole system into the building construction.

Five software subjects have been identified: they include development, evaluation and verification of models, systems analyses, and preliminary optimization studies based on available information. This information will be provided in part by measured data from some ten well-instrumented field experiments in residential buildings. These experiments are generally of limited size, although some of the experiments will concern up to 20 houses. Furthermore, five field experiments in utility buildings and another five in the agricultural area have been planned.

A number of projects address the social aspects of the introduction of solar energy for space heating. They include the development of consumer protective measures like standards, minimum property requirements, test procedures, etc. Further studies concern urban planning, building codes, possible legal aspects and, finally, regular updating of the predictions of introduction speed, cost and prices, and market development.

Although the majority of the projects relate to the active use of solar energy, at least 5 projects are planned. The entire space heating program includes 35 subjects covering some 50 projects. The budget allocated for this part of the program is about $5.2 million, plus contributions from other participants in the program for the period up to 1981.

Space Heating with Seasonal Storage

In preparation for the third phase of the national program, a number of rather fundamental research and development projects concerning seasonal storage have been formulated. Most of these are already under way. They include the building of a prototype in which heat is stored by the heat of adsorption of water on hygroscopic materials. In another project the thermal properties of soil are measured. Beyond this, a model of heat storage in soil is being developed which then will be used for a conceptual design of an actual storage system. Both the model and the design will be further verified by one or two medium size field experiments.

Long term storage in an artificial lake will be studied in a cooperative project near (Mannheim

in Germany), which is part of the IEA Implementing Agreement on Heat Storage. Finally a theoretical study will be made of a number of long term storage possibilities. Their technical and economical feasibility and merits will be studied and compared.

About $800,000 has been reserved for the current phase of this program.

Cooling and Climatization

Because of the large uncertainties with respect to the introduction of cooling and climatization in the Netherlands, the cooling program has a narrow scope. It consists of several theoretical studies which address the necessity of, and possible market for, cooling equipment in general and the feasibility of using solar energy for this purpose in particular. The budget for the present period is about $125,000.

Projects of General Interest

Five projects of general interest have been defined. One concerns the development of a climatological model of solar radiation on inclined surfaces. This model will be developed on the basis of new and improved measured data. It is important for improving the calculations on the performance of all kinds of solar energy systems.

A second important project in this category is participation in the European Communities Pilot Test Facility Program for both domestic and international verification of solar systems models and component testing. An additional subject of general interest is the identification of still existing corrosion problems and the undertaking of research on this subject.

FINAL REMARKS

Priorities for the Dutch national RD&D program on solar energy are set by the local climatological conditions, the local energy supply situation, the available budget, and the economic prospects of the different systems and techniques. The official program got a rather late start, but has developed quickly and now has some 20 projects on low temperature applications of solar energy under way. Other subjects, such as high temperature applications or solar electrical conversion, may be included in the national program at a later date. Wind energy is not included in the solar program; it is a separate item.

Although the program is restricted to low temperature applications, the program is very comprehensive. It includes fundamental research and development, software and technical development, field experiments, and medium- and large-scale demonstration projects. In addition, most social, economic and consumer-protection related subjects are addressed. The participants in the program span a very wide range from fundamental research institutions through the industry to the consumer.

The all-embracing character of the program coupled with its limited budget, does not allow for duplication of efforts. Therefore, cooperation both is sought both locally and at the international level. The latter has been established in part through the International Energy Agency and the European Communities.

Table 1. Funding 1st Phase	US$
• solar water heating	$2.5 m.
• space heating	$5.2 m.
• seasonal storage	$0.8 m.
• cooling	$0.1 m.
• general	$0.6 m.
• unforeseen	$0.8 m.

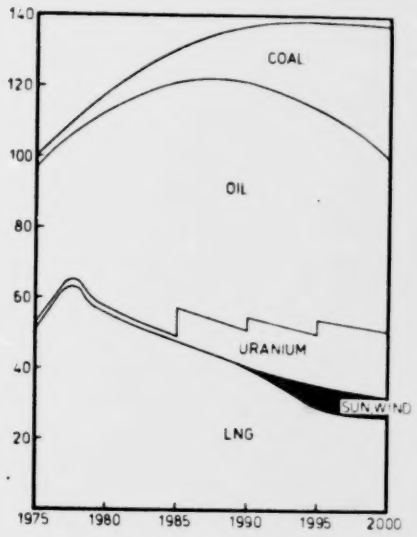

Figure 1. Projected Energy Consumption in the Netherlands.

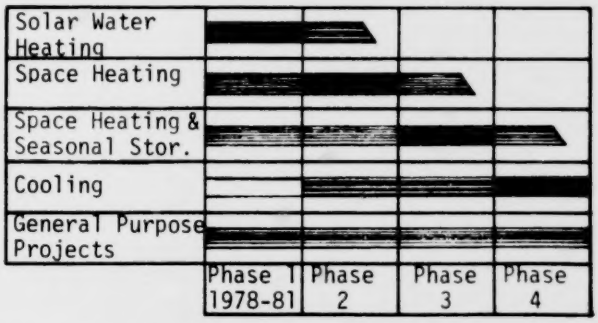

Figure 2. National RD&D Program on Low Temperature Application of Solar Energy.

NATIONAL SOLAR HEATING AND COOLING PROGRAM OF NEW ZEALAND

R. F. Benseman, M. A. Collins
Physics and Engineering Laboratory
DSIR
Lower Hutt

The direction, speed and viability of solar implementation in any country is the result of a unique combination of factors: climate, energy needs and sources, population; government policy and social expectations; technical and industrial capacity; and background experience in solar utilisation. Every country has a particular "solar thumb print," and every country may therefore be expected to have reached a level in solar heating and cooling development that is peculiar to its specific background. Here is the New Zealand background:

Location: South Pacific (latitudes 33° to 47°S) - 1600 km east of Australia.

Population: 3 100 000 in two major islands with an area of 27 million hectares.

Climate: • Insular. Average temperature 13°C and an annual range of from 8-11°C in populated areas. Temperatures above 28°C or below 4°C are unusual. • Well defined. (Five continuous Eppley stations since 1954, 72 Campbell-Stokes sunshine recorders).

Energy Use: • Per capita consumption equivalent to 3.2 kW continuous. • 35% used for low temperature heating, 25% for high temperature heating and power, 40% for transport. • Domestic use is well documented: hot water 44%; cooking 13%; lighting, heating, etc. 43%. • Industrial use is not known accurately, particularly in respect to temperature, - but there is a considerable amount of hot water used in the food processing industry. Commercial buildings are heated, but only in some areas of the country is summer cooling considered necessary.

Primary Energy Supply: • Coal 14%, • hydro and geothermal electricity 17%, • natural gas 16%, • oil (imported) 46%, oil (indigenous) 7%.

Energy Reserves: • Coal for several centuries, • natural gas with an estimated life in known reserves of 35 years, • considerable hydro and geothermal potential.

Sunshine: Average 2000 hrs/year; mid-summer K value 0.56; mid-winter 0.46; horizontal average 14 MJ/m^{2}day.

Residential Sector: One million houses, mainly single units, commonly 80-120 m^2. Extensive use is made of timber in construction. 99% connected to the national electricity grid.

Agricultural and Industrial Sector: • A large agricultural base (70% of total exports). • Engineering industry is generally small but versatile and often quite sophisticated. • Few energy-intensive industries other than aluminum smelting and pulp and paper production.

Energy Costs: The New Zealand Government regulates the prices of fossil fuels, i.e. oil, coal and natural gas. Typically, electricity is 3.48 cents/kWh* (cf. 1.15 cents in 1974, although annual inflation at 10-15% accounts for some of this increase).

Research and Development: In 1957 the Department of Scientific and Industrial Research (the major Government research organisation) started an investigation into "the place of solar energy in New Zealand's energy future." At that time there was no New Zealand solar industry. Because water heating (particularly domestic water heating) was a significant energy user, and because solar water heaters were a relatively advanced technology, research activities over 10 years were directed as follows:

1. Construction of an electrical/mechanical analogue capable of duplicating any general form of solar heating system. It was a forerunner of computers and could process one year's weather data in six minutes.

*$1 NZ = US $1.0235 (July 25, 1979).

2. Consolidation of available solar radiation and temperature data into normalised hour-by-hour "standard years" for each centre of population.

3. Determination of the performance of solar water heaters in each centre using the analogue and taking account of collector performance and area, solar tank capacity, thermostat setting, hot water demand, collector tilt and direction, etc., etc.

4. Installation of some monitored domestic solar water heaters to check the reliability of the computational procedures. Two of these are still operating.

5. Design of a frost-resistant solar collector specifically intended for use in the New Zealand climate, using indigenous materials (mainly steel), yet compatible with conventional copper plumbing.

6. Establishment of test facilities, including an indoor IR lamp assembly used for assessing collector performance during development studies, and an outdoor facility for comparing the relative performance of total solar water heating systems under realistic conditions of use.

By 1973 there was a small solar water heating industry, mainly servicing homes remote from the national electricity grid for which the alternative to solar heated water was no hot water at all. Three solar homes had been built privately. Since that date the industry has moved into an area where it sees potential expansion and profit. As a consequence DSIR has moved away from hardware development towards testing and research, and industry is now producing the hardware. Currently there are 15 commercially available domestic solar water heating systems on the market, and at least 10 others in the development process.

CURRENT ORGANISATION

The New Zealand Ministry of Energy (10) has the primary responsibility for the solar energy programme and the co-ordination of research and development effort. The Ministry's main function is to evaluate energy options and to administer incentive schemes used to promote activity in selected areas. The major research effort is carried out by DSIR with significant contributions from universities, other Government departments, and private firms. Total expenditure is difficult to estimate because R&D in solar is generally within an existing organisation. Thus, the DSIR staff involved are committed, not only to solar, but also to wood-burning appliances, thermal insulation, industrial liaison and computer engineering. Similarly, manufacturers may have as their principle business the manufacture of plumbing fittings, heating equipment or bicycles. The funds specifically allocated for solar development often include additional services or equipment; overhead and the cost of backup facilities are generally absorbed by the parent organisation. Identifiable funding is listed below.

	Funded Directly by Government	Industrial & University Funded
1977/78 (actual)	$137,000	$118,500
1978/79 (estimated)	157,000	99,700

The main Government programme is the DSIR testing and research schedule, but the Ministry of Works and Development has been installing solar water heaters in houses that they construct when they build new townships as part of large development schemes. In these cases the monies supplied are for instruments to monitor performance. The Meteorological Service is similarly funded for a solar resource investigation. The breakdown of expenditure within these Government departments is shown in the following table.

	1977-78 $ (000)	1978/79 Estimated $ (000)
DSIR	127	147
Met. Service	5	8
MOWD - Domestic	5	2.5
	137	157

Major non-Government projects involve development of improved solar water heaters and the use of solar energy to dry industrial waste. Two projects not included in the funding described, but of some relevance, are investigations of solar boosted heat pump performance, and low energy housing research - this latter relates to the use of passive solar space heating systems.

INCENTIVES

There has been a very significant increase in domestic consumer interest in solar water heaters since the middle of 1978. This was the result of two incentives. The first was a Government budgetary announcement that approved solar water heating systems would be eligible for a $300 or $500 interest-free

loan to be paid back over a period of 4 years. (Note: a domestic solar water heater in New Zealand costs about $1,200 installed). The second incentive was an almost 50% rise in retail electricity charges. Since 93% of homes use electrically heated hot water, nearly every household was affected. The result of these two measures has been a surge of consumer interest in retrofitting domestic solar water heating units. Tax incentives are available to commercial and industrial consumers to install solar water heaters.

SUMMARY OF CURRENT ACTIVITY

The table below shows the main areas of development.

ACTIVITY	SPECIFIC APPLICATION	RESPONSIBLE AUTHORITY
Solar Water Heating		
Collectors:	Testing thermal performance	Dept. Scientific & Industrial Research (DSIR) (1)
	Material & construction appraisal	Building Research Association of NZ (2)
	Innovation	Industry
Systems:	Monitoring under specified conditions	DSIR
	Monitoring in homes	DSIR, Housing Corporation (3) Local Authorities
	Demonstration in homes and commercial buildings	Ministry of Works & Development (4)
System Design:	Hot water for food processing	
	" " " hospitals	DSIR
Non-domestic Use:	Food processing, institutions, motels, swimming pools	Industry
Agriculture:	Dairy water heating	Ministry of Agriculture & Fisheries, (5) Massey University (6)
Space Heating		
Passive:	Housing	Private home owners, University Architectural Schools (7)
Active:	Housing	Private home owners
Thermal Storage	Investigation of seasonal storage	DSIR
Solar Drying	Drying of herbs and fruit	Industry, DSIR
Solar Radiation	Data collection and analysis	NZ Meteorological Service (8)
	Computation	DSIR
Standards	C.O.P. Testing	Standards Association (9) DSIR

TESTING, CONSUMER PROTECTION

The previous table shows the range of activities being carried out by Government departments and industry. The main thrust is the supply and testing of solar water heaters mainly for domestic use. Government sponsorship of approved solar water heaters has accelerated the need for an independent authority to test and approve (or otherwise) the many products currently on the market.

System Testing: At the time of the Government announcement, DSIR was already constructing a comprehensive testing facility for the Ministry of Energy. Designed initially for R & D activities, the test structure has now been dedicated to evaluating the thermal performance of solar water heaters designed for retro-fitting to homes. In the test, 15 solar water heaters and their associated electrical boosting tanks installed in a house-like structure, have hot water drawn automatically in specified quantities, at specified temperatures, and at specified times of each day. A sixteenth circuit monitors a conventional electrically heated hot water supply. The difference between the energy used by the fully electric system and any solar assisted unit represents the contribution of the solar component. The tests that are now in progress will continue for one year and the results made available to the public.

Collector Testing: Apart from the indoor IR lamps that are used for evaluating performance during development work, an outside testing facility has also been available for some years. Tests were previously carried out along lines recommended by the CSIRO in Australia and by the National Bureau of Standards in the USA. The procedures and methods of calculation have now been firmed up to comply with ASHRAE 93-77 and the IEA Recommendations for Testing of Solar Collectors. As part of the IEA programme, one American and one English collector have been tested in a "round robin" evaluation of testing procedures and facilities. A spectrally acceptable indoor test rig is currently being assembled. This will allow more convenient testing under more controlled conditions.

Tanks: Insulated tanks for solar installations are covered by a New Zealand Standard specification relating to electrically heated hot water storage systems. This is an adequate coverage.

Installation: The New Zealand Standards Association has sponsored the preparation of a Code of Practice for installation of solar water heaters. Representatives of consumer groups, electrical supply authorities, plumbers, and the Solar Equipment Manufacturers Association have prepared a brief document which is intended to guide local authorities in their work of inspecting new systems and ensuring that workmanship, procedures and materials are of the highest standard.

Pumps: While thermosiphon systems are preferred in areas where frost (freezing of collectors) is no problem, pumps are sometimes substituted for reasons of ease of installation and as protection against freezing. The small pumps (100 W approximately) required for this type of service are generally imported and 8 different models are currently on test. The tests have been running for 12 months and some units have already been rejected as unsuitable.

Appraisal: On behalf of the Ministry of Energy, the Building Research Association of New Zealand carries out appraisals of solar water heating systems. This involves examination of all components used in a complete system. The product is followed from manufacture through sales and installation to after-service procedures. The examination covers all relevant features: materials, construction, quality control, instruction manuals for installers and users, servicing facilities, advertising claims, guarantees, etc. Data on thermal performance (usually supplied by DSIR) is used to set minimum collector areas for each product. After a successful appraisal has been made (i.e. a favourable technical opinion has been given), and other conditions have been met, the Ministry of Energy registers the product as one approved for the loan incentive. A four-year guarantee on the product and two years on its installation are two requirements. Nine solar water heating systems have been approved under this scheme, but many others are in the process of being appraised.

SUMMARY AND CONCLUSIONS

The direction and rate of progress of solar utilisation in New Zealand has been conditioned by the particular energy and climatic structure. In practical terms, solar water heating has always been the obvious and logical line for development in terms of economic viability. The

temperature requirements are modest, the technology proven, the equipment simple, and there is a demand for hot water every day of the year. Potential energy savings under a wide range of conditions have been established as a result of 20 years of research and development. The move to exploitation on a larger scale has been triggered by government incentives, rising energy costs, and commercial interest in a new and expanding industry. In the last year the main change in government emphasis has been from servicing and developing an industry to supplying consumer information about the performance of the many options. This has required assessments of thermal performance under realistic conditions and assurance that equipment and installation are of a high quality.

The next logical step for New Zealand is research directed to the problem of long-term thermal storage. It is recognized that this problem will need to be solved if solar heating is to become a self-supporting alternative to conventional energy sources. Solar water heaters are now an established feature of New Zealand housing, and although the total number of systems installed (≈10,000) is not actually known, activity is expected to increase. The extension into commercial and industrial environments is also accelerating. The national programme now is tending towards a monitoring and supervisory function with industry taking the initiative in producing solar hardware.

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(6) Dairy Division, Massey University, Private Bag, Palmerston North.

(7) Architectural School, Auckland University, Private Bag, Auckland.

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(9) Standards Association of N.Z., Private Bag, Wellington

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SOLAR HEATING '85
SWEDEN'S NATIONAL SOLAR HEATING PROGRAM

Lars O. Matsson
Solar Energy Association of
Scandinavia
VVS-Tekniska Foreningen
Hantverkargatan 8
S-112 21 Stockholm

ABSTRACT

In this report the new Swedish national program on solar heating. Solar Heating '85 is summarized. The program is an escalation of the present program. The main emphasis of the program is on research & development and demonstration. The research efforts will, to a great extent, be concentrated upon storage systems.

1. INTRODUCTION

An energy bill, presented to the Parliament in March this year, the new Government introduced the Solar Heating '85 program, an updated and escalated version of the present program. The main objective of Solar Heating '85 is to give enough experience and knowledge to permit a complete evaluation of the prospects for solar heating in Sweden at the end of the next 3-year planning-period, i.e. 1984. The major elements and key activities of the program are identified in Fig. 1

Fig. 1. Major elements of the Solar Heating '85 program.

SOLAR HEATING '85

MAJOR ELEMENTS	KEY ACTIVITIES
R&D	- STORAGE SYSTEM DEVELOPMENT - DOMESTIC HOT WATER SYSTEMS - SOLAR RADIATION DATA
DEMONSTRATION	- EXPERIMENTAL BUILDING PROJECTS
STANDARDS	- INTERNATIONAL COOPERATION (IEA)
MARKETING	- GOVERNMENT BUILDINGS - MILITARY BUILDINGS - HOSPITALS - DAY NURSERIES
GOVERNMENT INCENTIVES	- ADJUSTMENTS OF THE BUILDING CODES AND THE TERMS FOR HOUSING LOANS - GRANTS TO DOMESTIC HOT WATER SYSTEMS - INFORMATION AND EDUCATION
COORDINATION	- THE DELEGATION FOR SOLAR HEATING

2. RESEARCH, DEVELOPMENT AND DEMONSTRATION

The two elements Research & Development and Demonstration are very closely connected to each other. Demonstration is often the natural continuation of a successful development effort. The main emphasis of the Solar Heating '85 program is on these two elements.

The following are the objectives of the program.

- the program must focus on the development of technology that conserves energy and is socially and economically viable.
- a complete evaluation of the prospects for solar energy in Sweden will be undertaken by 1984, forming the basis for future programs.
- the program must support the development of a viable Swedish solar industry.

The Swedish Council for Building Research (BFR) is responsible for the program. It administers grants for research and development and for planning and evaluation of demonstration projects. In addition, the BFR provides un-amortized, interest-free loans to cover experimental costs of demonstrations (which are called "experimental building projects"). These loans can be written off after the project has been evaluated. Nearly all building projects are eligible to receive the loans: multiple-unit dwellings, office buildings, detached houses, public buildings, swimming pools, etc.

Grants for industrial development work are given by the National Swedish Board for Technical Development, but coordinated with BFR by the Delegation for Solar Heating. The organization is shown in Fig. 2, the funding level in Fig. 3 and the lines of development in Fig. 4.

Fig. 2. Organization of R&D and experimental building projects.

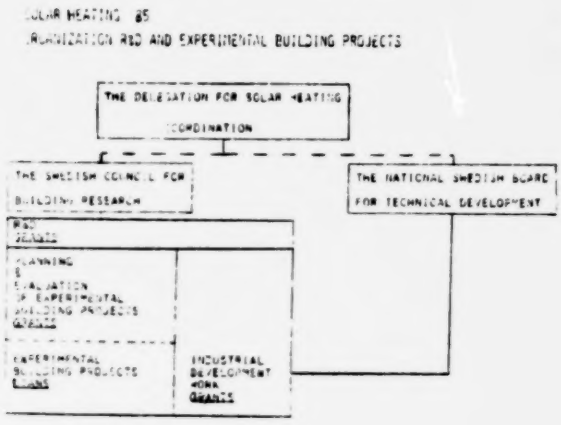

Fig. 3. Funding of R&D and experimental building projects. M skr.

THE SWEDISH COUNCIL FOR BUILDING RESEARCH

FUNDING LEVEL DURING THE PRESENT 3-YEAR PERIOD

FY	78/79	79/80	80/81	TOTAL
GRANTS TO R&D AND PLANNING & EVALUATION OF EXPERIMENTAL BUILDING PROJECTS	14.5	32.5	36.0	84.0
GRANTS TO INDUSTRIAL DEVELOPMENT WORK	4.0	4.0	4.0	12.0
LOANS TO EXPERIMENTAL BUILDING PROJECTS	16.0	32.0	32.0	80.0
TOTAL	34.5	68.5	72.0	176.0

FY = 1. JULY - 30. JUNE 1 SKR=0.23 US $

Fig. 4. Lines of development.

LINE OF DEVELOPMENT	PLAN	PRELIMINARY PLAN	ROUGH ESTIMATE
FY	79/79-80/81	81/82-83/84	84/85-86/87
WATER HEAT STORAGE	35 (25) M SKR	66 (45) M SKR	25 (20) M SKR
GROUND HEAT STORAGE	35 (11)	70 (25)	60 (?)
BOTTOM SEDIMENT HEAT STORAGE	20 (5)	20 (10)	25 (?)
CHEMICAL HEAT STORAGE	20 (4)	30 (13)	40 (?)
SOLAR HEATED DOMESTIC HOT WATER	54 (32)	20 (4)	-
OTHER R&D EFFORTS	32 (3)	40 (5)	40 (?)
TOTAL (LOANS)	176 (80)	236 (103)	180

FY = 1. JULY-30. JUNE 1 SKR = 0.23 US $

2.1 Heat Storage in Large Volumes of Water (Solar Heat Stations)

A typical solar heating system on the market today includes a small water tank for heat storage. This method of heat storage is well proven, but the large energy losses make only short term storage possible. Heat storage in very large volumes of water. However, resolves this problem. As the storage volume increases, heat losses decrease compared to the energy stored. In addition, heated water is readily used in known heating and distribution methods.

The work with solar heating of buildings has concentrated on the development of solar heat stations. One prototype was built during spring 1978 and evaluated. Two smaller stations for heating of detached houses in groups in Vaxjo and Linkoping are now under construction. Studies are being made of different types of solar collectors, collector orientation, temperature level, storage systems, etc. At least two more solar heat stations will receive grants during this period (FY 1979-80/81). One of these will be a "half-scale" unit (equal to 50-150 flats) whose purpose is to utilize the experiences of earlier projects. Another purpose of the half-scale projects is to introduce and demonstrate the technique to local governments, consultants, contractors and the public.

In parallel with the development work on the solar heat stations, research will start on material and construction problems, optimum design, operating strategy, etc.

The program on solar heat stations is summarized in Fig. 5.

Fig. 5. Water heat storage program.

WATER HEAT STORAGE (SOLAR HEAT STATIONS)

FY		TOTAL (LOANS)
78/79-80/81	R&D 1 PROTOTYPE 3 HALF SCALE PROJECTS	35 (25) M SKR
81/82-83/84	R&D 2 HALF SCALE PROJECTS 1 FULL SCALE PROJECT	66 (45)
EVALUATION 84/85-86/87	R&D DEMONSTRATION	25 (20)

FY = 1. JULY-30. JUNE 1 SKR=0.23 US $

2.2 In-Ground Heat Storage

The field of in-ground heat storage has been divided into the subgroups

- deep ground storage,
- ground surface storage,
- ground water storage.

Deep Ground Storage

By using soil or rock layers from 10 to 200 m deep, heat can be stored during long periods in large-scale storages with small energy losses. Results of computer simulations and tests in single drill holes have shown that the technique is feasible. The heat is stored at low temperatures, 10-50°C, and heat pumps are used in some systems. The low temperature level is a critical aspect of this technique since high flows and large heat-giving areas are required. Full-scale projects must be carried out to verify the results from theoretical calculations. The following combinations will be investigated furing the present period.

--Rock storage - solar collectors - heat pump.
--Rock storage - heat pump - passive geohydrological charging through flowing ground water.
--Rock storage - solar collectors.
--Clay soil storage - solar collectors - heat pump.
--Clay soil storage - solar collectors.
--Storage with loose types of soil - solar collectors - heat pump.

Some of the heat pumps may be diesel powered.

Due to the long time it takes to build storage systems like these, the evaluation of the projects will begin during the next planning period, FY 81/82 - 83/84.

Ground Surface Storage

Solar heat can be stored in a passive way in the surface layer of the ground by solar insolation during the summer period. This energy can be utilized by a heat pump, which cools the ground via pipes approximately 1 m deep. Storage systems of this type are now on the market in Sweden, but more development is needed. One of the many problems is the design of the pipe system in the ground. A proper design, especially of the dimensions, is important since a large ground area is required and this often is limited.

Ground Water Storage

Projects of this kind will be supported only in exceptional cases.

The ground heat storage program is summarized in Fig. 6.

Fig. 6. Ground heat storage program.

GROUND HEAT STORAGE

FY		TOTAL (LOANS)
78/79-80/81	DEEP GROUND STORAGE 6 HALF SCALE PROJECTS	30 (10) M SKR
	GROUND SURFACE STORAGE 1 FULL SCALE PROJECT	5 (1)
81/82-83/84	DEEP GROUND STORAGE 12 HALF SCALE PROJECTS	65 (25)
	COMBINED SYSTEM 1 PROJECT	5 (1)
EVALUATION		
84/85-86/87	DEEP GROUND STORAGE 10 FULL SCALE PROJECTS	60 (?)

FY = 1. JULY-30. JUNE 1 SKR=0.23 US $

2.3 Bottom Sediment Heat Storage

At present no studies have explored the possibility of using lakes as large-scale heat reservoirs with heat pumps. Some projects have attempted to enclose and heat a small part of a lake with solar energy. Of special interest is the possibility of using lake bottom sediment to store energy. The main problem with the use of heat pumps in connection with lakes is the heat exchanger. Different types of heat exchangers must be developed for this purpose. At the same time, research on the limnological and ecological consequences of lake bottom sediment storage must be undertaken. The bottom sediment heat storage program is summarized in Figure 7.

Fig. 7 Bottom sediment storage program.

BOTTOM SEDIMENT HEAT STORAGE

FY		TOTAL (LOANS)
78/79-80/82	5 HEAT EXCHANGER PROTOTYPES	10 (5) M SKR
81/82-83/84	5 PROTOTYPES 5 FULL SCALE PROJECTS	20 (10)
EVALUATION		
84/85-86/87	5 FULL SCALE PROJECTS	15 (?)

2.4 Chemical Heat Storage

This storage technique can be divided into three subgroups.

- Latent heat storage (phase-change storage
- Thermo chemical heat storage.
- Chemical heat pumps.

Latent Heat Storage

The problems that have been studied here are reversibility, phase separation, charging and discharging, undercooling, change in

volume, long term stability, corrosion etc. Some development work is carried out in Sweden and this will continue during the next two planning periods with laboratory- and full-scale tests.

Thermo Chemical Heat Storage

This is a new and yet undeveloped technique to store energy. The Swedish activities will be to follow-up the work done in other countries and to participate in international projects in order to gain increased knowledge. Some studies in laboratory-scale will be done. The environmental effects will also be studied.

Chemical Heat Pumps

The chemical heat pump functions both as an energy storage and as a heat pump. The storage is charged at a low temperature and discharged at a higher temperature. In one project this temperature difference is 55°C. The technique is very promising and some full-scale tests are planned for the present period.

The chemical heat storage program is summarized in Fig. 8.

Fig. 8. The chemical heat storage program.

CHEMICAL HEAT STORAGE

FY		TOTAL (LOANS)
78/79-80/81	R&D, PROTOTYPES	
	LATENT HEAT STORAGE	2 (1) M SKR
	THERMOCHEMICAL HEAT STORAGE	6 (4)
	CHEMICAL HEAT PUMPS	5 (2)
81/82-83/84	R&D, PROTOTYPES	
	LATENT HEAT STORAGE	6 (4)
	THERMOCHEMICAL HEAT STORAGE	15 (5)
	CHEMICAL HEAT PUMPS	9 (4)
EVALUATION		
84/85-86/87	R&D, PROTOTYPES	
	LATENT HEAT STORAGE	6 (?)
	THERMOCHEMICAL HEAT STORAGE	15 (?)
	CHEMICAL HEAT PUMPS	19 (?)
FY= 1. JULY - 30. JUNE		1 SKR=0.23 US $

2.5 Solar Heated Domestic Hot Water

The technique for using solar energy to provide domestic hot water is well known. In Sweden, the major problem encountered by water heating systems is the long term maintenance of the quality of the solar collectors, since the Swedish climate is perhaps harsher than that of other countries using solar energy. To alleviate this problem, testing of collectors and other hot water system components is being undertaken. Further work is needed, especially on the development of stands and integrated installations. The solar domestic hot water program is summarized in Figure 9.

Fig. 9. Solar heated domestic hot water program

SOLAR HEATED DOMESTIC HOT WATER

FY		TOTAL (LOANS)
78/79-80/81	R&D 3 PROTOTYPES 70 FULL SCALE PROJECTS	54 (32) M SKR
81/82-83-84	R&D 10 FULL SCALE PROJECTS	10 (4)
EVALUATION		
84/85-86/87	-	-
FY = 1. JULY-30. JUNE		1 SKR=0.23 US $

2.6 Other Research & Development Efforts

In addition to the above-mentioned work, more general and fundamental research & development must be done. This work focuses on design manuals, solar collectors, computer programs, distribution systems, materials and heat-giving systems. The program is summarized in Fig. 10.

Fig. 10. Other R&D efforts program.

OTHER R&D EFFORTS: DESIGN MANUALS
COMPUTER PROGRAMMES
SOLAR COLLECTORS
DISTRIBUTION SYSTEMS
MATERIALS
HEAT-GIVING SYSTEMS

FY	TOTAL (LOANS)
78/79-80/81	32 (2) M SKR
81/82-83/84	40 (5)
EVALUATION	
84/85-86/87	40 (?)
FY = 1. JULY - 30. JUNE	1 SKR=0.23 US $

3. STANDARDS

Sweden participates in Task III of the IEA Program to Develop and Test Solar Heating and Cooling Systems: Performance Testing of Solar Collectors. The organization responsible for this participation is the Swedish National Authority for Testing, Inspection and Metrology (SP). The SP is working in cooperation with the National Board of Physical Planning and Building on methods for voluntary testing of solar collectors, and with the Swedish Building Standard Organization on development of standardized Swedish terminology for solar energy. Most important, it is cooperating with the Swedish Standard Association in development of a Swedish standard for solar collector testing. The SP has already developed one method for solar collector testing (SP-C12-301) which is based on the ASHRAE and BSE methods. Studsvik Energiteknik AB, a research company owned by the government, also has a solar simulator and can test different types of solar

collectors. The National Swedish Board for Consumer Policies working with the SP is planning comparative consumer oriented tests of solar collectors on the market.

4. MARKETING

The Swedish Government is very interested in installing solar heating equipment in public buildings in order to introduce the technique into the market and to support manufacturers. The National Swedish Board of Public Building builds and administrates all civil governmental buildings. This makes it a very important factor in the Swedish building market and its influence on the development of the solar heating market is considerable. It is studying the technique and will shortly install solar collectors on a few buildings. Military buildings are the responsibility of the Royal Swedish Fortifications Administration, which is following the development of, but has so far not installed, solar collectors. The country councils are also important factors, mainly because they administrate the hospitals. Several studies of solar heating in different kinds of nursing institutions have been made. Some installations will probably be made in the near future. Local governments have had perhaps the greatest impact on the development of the market. Local governments are involved in the construction of all solar heat stations, of five swimming-pools (of which four are built), and of one day nursery. Public opinion is very much in favour of solar heating. As decision makers in the local governments are elected, their activities in this field will increase.

5. GOVERNMENT INCENTIVES

The government promotes the use of solar heating by

- grants and loans to certain types of solar heating systems
- adjustment of laws and regulations in favour of solar heating
- public and industry information and education about solar heating technology

The National Swedish Housing Board gives grants and loans to solar heated domestic hot water systems in residential buildings. The total amount of grant and loan is Sw.Crs. 1000* per m^2 of collector area up to 8 m^2 per flat or single family house. The grant is 35% and the rest is loan. For solar heating projects in industrial buildings grants and loans can be given by the National Swedish Industrial Board. The amount is decided in each separate case.

Building codes are continuously adjusted according to the development of building technology. Special attention will be given to solar heating and heating systems with temperature levels favourable to solar heating. The organization responsible for the building codes is the National Board of Physical Planning and Building.

Information about solar heating is given to the public by the Energy Conservation Committee, while the industry is informed by the Regional Development Funds.

In addition to the activities of the technical institutes, education in solar heating is organized by the National Swedish Industrial Board.

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*1 SwCr = US $.2380 (July 25, 1979)

SPANISH SOLAR ENERGY PROGRAM

Dr. A. Muñoz-Torralbo
Centro de Estudios de la Energia
Augustin de Foxa 29
Madrid 16

INTRODUCTION

The challenge of limited energy resources may be met by making a serious effort in the development and generalized use of renewable energies. This paper describes the objectives, activities and programs in this field carried out by the Centro de Estudios de la Energía (Energy Research Center) of the Spanish Ministry of Energy and Industry.

Among the renewable energies, solar energy is considered, in the short term, the resource most likely to make a significant contribution in Spain. Each specific solar application will be affected by the climatologic conditions and the urbanistic and socio-economic context of each country. A direct transfer of applications, experiences or programs from one country to another therefore appears to be impractical. Some sort of adaptation is always required. The programs listed below have been adapted, in most cases, to the specific conditions prevailing in Spain.

The activities of the Centro de Estudios de la Energía in the field of solar energy include:
- Direct thermal applications of solar energy
- Generation of electricity by means of thermodynamic cycles
- Photovoltaic electricity

DIRECT THERMAL APPLICATIONS

a) Basic solar technology

In order to help the industry, designers, and installers of solar equipment, a number of programs have been implemented, in some cases in cooperation with the IEA Solar Heating and Cooling R & D programs.

- Test installation for solar collectors

In collaboration with INTA, a test stand has been installed on the premises of the institute. This facility is currently being used by industrial and residential builders for the development and testing of their products.

- Radiation data

There are two different programs with a common objective of diffusing the necessary radiation and climatolgic data to be used in system design: A Radiation Handbook suitable for simple, straightforward system evaluation, and production of 13 magnetic tapes with hourly data recorded over a five year period from 13 different locations. In addition, a "Year Type" tape has been devised for each one of the 13 locations.

- Design and simulation methods for solar systems

In order to fulfill the need of potential solar equipment users, a number of design and simulation methods for solar systems have been developed:

- Basic Handbook for System Design
- Advanced computer-based design method
- Interactive conversational computer-based design method.

b) Analysis of Solar Energy Applications in the industry.

This program is almost completed at the present time. As a framework, a questionnaire about the hot water consumption profile in industry has been sent out to more than 30,000 different companies. Based on the results obtained from the survey, a number of solar systems have been carefully analyzed as to their capability for meeting these industrial hot water loads. Each company that responded to the questionnaire has received an individualized reply. In those cases in which solar energy seemed to be economically feasible, a detailed report was issued showing the main parameters, technical aspects and economic performance of the system.

c) Advanced desalinization systems

Simple desalinization systems have proved to be uneconomical in Spain. A solicitation was issued to promote the development of an advanced solar desalination system which could be

economically operated in some arid coasts of the Canary Islands. This effort led to the R & D project for the construction of a "Multiflash" desalinization system which will be in operation by mid 1980. The specified water production capacity of the system is $10m^3$ per day, to be raised to $100m^3$ per day.

d) Demonstration Programs

A number of demonstrations of large solar systems for hot water production in public buildings are already in operation. Some others are being constructed or are in the proposal stage. All the installations are on visible public sites. At the present time the following installations are in operation:

Hospital Civil in Malaga, $360m^2$ of collectors, $26m^3$ of storage
Residencial Espinardo in Murcia, $260m^2$ of collectors, $20m^3$ of storage
Hospital Sagrada Familia in Tenerife, $300m^2$ of collectors, $4m^3$ of storage
Hospital Insular in Las Palmas, $350m^2$ of collectors, $26m^3$ of storage

Seventeen installations of this type will be operating by late 1980. Each system will be equipped with a complete data recording system and a meteorological station that will allow the calculation of energy balances and the evaluation of the overall performance of the system.

e) Experimental solar energy collection and storage for heating greenhouses.

A program has recently been initiated to develop cheap solar collectors for heating greenhouses on cold, clear nights. The collectors consist of black plastic bags in which water flows at very low speed. Those bags are placed on the ground, in the middle of the growing space. A large greenhouse has been installed with this system in "Campo de Dalias" in Almeria. Experiments will start next autumn.

f) Information Program

In order to promote the use of solar energy systems and the development of a related industry, a number of information activities are being carried out. In addition to the above-mentioned activities:

- Publication of a monthly newsletter called "Información de Energía Solar."
- Publication of a catalog of manufacturers of solar equipment.
- Publication of technical literature.
- Participation in courses and seminars.
- Press campaigns.

II. SOLAR THERMAL GENERATION OF ELECTRICITY

This technology is in an early stage of development. The most important problems to be solved are reduction of costs and attainment of reliability of the overall system. Nevertheless, generation of electricity from solar energy by thermodynamic methods appears promising in Spain. The following activities are underway in this area.

a) CESA-1 Project

This project involves the design, construction and operation of a pilot Solar Power Plant of 1 MW_e nominal output. The pilot plant will be installed in Almeria, in a site that has been named "Plataforma Solar de Almeria." The basic structure and engineering work have been completed. Heliostats and solar receivers are under development and the turbogenerator and control are under solicitation. The plant is expected to be in full operation by mid-1981. The essential characteristics of the power plant are as follows:

Nominal power: 1 MW_e
Cycle: Superheated steam and thermal storage in molten salts
Reflecting surface: 9,900 m^2
Heliostats: 274 in north field
Control: Open Loop Control

Sandia Labs has collaborated on this project.

b) SSPS Projects

In the framework of the International Energy Agency, a program has been implemented to construct and operate two solar systems for electricity production. The central receiver system (CRS) is based on the central tower concept and the Distributed Concentrator system (DCS) on parabolic troughs.

The Implementing Agreement for the construction phase was signed on the 22nd of May 1979. At the present time, eight IEA member countries are participating. Italy is expected to join the project soon. The present budget is $US 41.2 million over the next four years.

III. PHOTOVOLTAIC GENERATION OF ELECTRICITY

The Centro de Estudios de la Energía has performed an assessment study to assess the program direction for a future photovoltaic R&D program. Very advanced negotiations are in progress with the most active Spanish group in the field (politechnic University of Madrid) and an agreement for the development of an active application orientated photovoltaic program will be reached shortly.

THE UNITED KINGDOM SOLAR HEATING PROGRAMME

D W Jefferson-Loveday
Energy Technology Support Unit
Harwell, Oxfordshire

for the UK Department of Energy

1. THE GOVERNMENT PROGRAM

In June 1978 the UK Government confirmed the continuation of the Department of Energy's £3.6 million* four-year research and development programme on solar energy which commenced early in 1977. With other money being made available, the total government expenditure on the subject will be about £6m over the period. It is expected that nearly two-thirds of this sum will be devoted to research and development of solar heating.

The Department of Energy's assessments of the potential contribution of solar energy within the UK identified the provision of low grade heat for water and space heating, which accounts for possibly 30 per cent of the country's primary energy demand, as having the greatest potential return. The major part, £2.8 million of the Department's £3.6 million programme, is therefore being directed towards support of R&D in this area, largely in support of industrial research already being carried out.

1.1 Organisation of the Government Programme

The Department of Energy is responsible for a substantial part of the UK Government's solar heating programme. The Secretary of State's Advisory Council on Research and Development for Fuel and Power (ACORD), under the chairmanship of the Department's Chief Scientist, maintains a watching brief over all new sources of energy and is charged with identifying promising new lines of research and development and making recommendations for further programmes to the Secretary of State for Energy. The Chief Scientist, advised by ACORD, maintains a regular review of the programmes. The government considers that while alternative energy sources are likely to make only a modest contribution to the total UK energy supply by the end of the century, their contribution could well begin to build up usefully in the first quarter of the next century. In the current state of solar water heating techn logy, the Government does not consider that there is an independent case at present for financial assistance towards installing solar water heating equipment. The present limitation to making faster progress is the state of the technology rather than the level of Government funding.

The Energy Technology Support Unit (ETSU) is coordinating and managing on a day-to-day basis the Department of Energy's research and development programmes on alternative energy sources, including the solar energy programme. Members of ETSU are appointed as project officers to supervise the work carried out on contract for the Department of Energy. From the start of the solar heating programme in February 1977, 40 R&D contracts have been initiated and are described in detail in Appendix I. The total commitment is £3.3 million and the Department of Energy's share of the cost of this work will be £2.5 million. Other government departments involved in the overall programme include the Department of the Environment, which is working on solar space heating (largely at its Building Research Establishment), on storage, and on the use of heat pumps and the design and orientation of buildings to make the most effective use of solar energy. The Department of the Environment is also examining the implications of solar energy collection in housing density, layout and construction, and is helping to establish standards for solar appliances.

The Department of Industry offers assistance to the solar industry on certain types of projects to develop manufacturing processes or products and to improve production facilities. (See Table 1)

1.2 Solar Water Heating

Systems for the solar heating of domestic and industrial water are already commercially available. But the cost of energy

*£1 = US $2.28 (July 25, 1979).

TABLE 1

GOVERNMENT SOLAR HEATING PROGRAMME PROJECTS

CONTRACTOR	PROJECT AREA	TOTAL COST (to nearest £'000)
John Laing R&D	Domestic hot water systems	40
Refrigeration Appliances	Collector development	60
Atkins R&D	Domestic hot water system design study	38 (C)
The Calor Group	Water and space heating systems	335
Pilkington Brothers	Monitoring of domestic systems	274
Thor Cryogenics/Wilmot Breedon	Water heating system	86
University College, Cardiff	Collector performance tests and standardisation (IEA Task III)	38
University College, Cardiff	Water heating system design optimisation and validation	20
University College, Cardiff	Phase-change thermal storage	31
University College, Cardiff	Monitoring of large-scale field trial	15
University College, Cardiff	Transient conditions collector testing	9
University College, Cardiff	Solar radiation measurement	38
Satchwell Control Systems	Pump and controller	60
Building Research Establishment	80-house water heating field trial	388
Metra Consulting	Industrial applications assessment	10 (C)
Pondar Tech. Associates	Water heating installation and component interaction	25 (C)
TI Research Laboratories	Superplastic aluminium/stainless steel collector and large-scale field trial of product	82
GEC Mechanical Engineering Lab/ Leicester Area Health Authority	Collector development and field trial on large-scale system	102
Faber Computer Operations	Heating and cooling system model validation (IEA Task I)	96
Steels Engineering	Domestic hot water collector and system	102
Fortress Engineering	Semi-focussing collectors	40 (C)
Sealed Motor Construction	Pumps and controls	45
University of Bath	Monitoring of large-scale water and space heating system	46
Meteorological Office	Insolation data (IEA Tasks IV & V)	5
Milton Keynes Development Corp	Passive heating	158
Milton Keynes Development Corp	Passive heating	139
IDC Consultants	Industrial water & space heating and storage	18
Redland Limited	Collector roof fixing	43

CONTRACTOR	PROJECT AREA	TOTAL COST (to nearest £'000)
John Laing R&D/Calor Group	Water and space heating	266
BSRIA	Pilot test facility - model validation and system development (with EEC)	140
South London Consortium	Monitoring of 14 house field trial	64
SW Region Health Authority	Monitoring of large-scale water heating system	64
Bifurcated Engineering	Collector development	53
Wimpey Laboratories	Domestic air space heating and storage	96
Cheshire County Council	Large-scale water and space heating	92
Under negotiation	Monitoring of water heating system	78
City University	Storage in the ground	4
University of Strathclyde	Air-heating collectors	17
University of Lancaster	Tubular collectors	40
INCO Europe	Selective surfaces	60

(C) - Completed

from these systems compared with conventional energy costs in the UK is, in general, still too high for the widespread adoption of such systems. For example, a 4 or 5m^2 domestic installation costing £600-£800 will give a saving of some £40 per year when costed against the standard electrical water heating system. A household using a natural gas boiler for water heating might save perhaps half of this. The programme is therefore aimed at stimulating the development of more cost-effective systems and at the same time obtaining a wider understanding of the factors affecting cost and performance. These aims are being met by supporting initiatives by research centres and by industry, or by major potential users of solar heating.

Progress is being made in three main directions:

- the support of shared-cost projects in industry on the development of component and system technology so that well designed and tested components and optimised systems are available;

- the measurement and analysis of system performance on full-scale field trials with collector areas ranging up to 200m^2 and with differing usage patterns. These will provide meteorological, system and demand data for the validation of the mathematical design models, together with information on cost and practical aspects;

- support for laboratory studies of more general problems such as installation, resistance to wind damage, surface finishes and test methods, and for assessments of various fields of application.

The program is not yet sufficiently advanced for predictions to be made on the likely long-run production and installation costs. It appears unlikely that a major breakthrough will be forthcoming; improved cost-effectiveness more probably will arise from a steady improvement in system efficiency, and reductions in production and installation costs.

1.3 Solar Space Heating

The more diverse technology of solar space heating for use under UK conditions is less well advanced than the simple water heating techniques. The Department of Energy's programme is being formulated on lines similar to that of the water heating programme in collaboration with other Government departments, particularly the Department of the Environment, and with research organisations, industry, housing associations and local authorities.

The overall aim of the solar space heating programme is the development of a largely established technology to suit UK conditions by a process of adaption and refinement. Beginning with shared-cost projects with industry on research on solar collectors and other components which could contribute to the development of effective heating systems, the programme is extending to other aspects of space heating and building design to identify systems which are likely to lead to optimum designs. Included in the programme are studies on passive systems, ranging from simple orientation and fenestration to Trombe-type walls, and different forms of active space heating, some in conjunction with wider technologies such as heat pump and thermal storage. The latter includes work on sensible heat methods in water and soil, and chemical and latent heat storage. The potential attractiveness of the use of air as the heat transfer fluid is recognised within the programme. There are indications that the more simple passive system may contribute about a quarter of the space heating requirements of a building at a cost competitive with current fuel prices, provided the site costs to obtain the optimum building orientation are not excessive.

2. RESEARCH OUTSIDE THE GOVERNMENT PROGRAMME

In addition to the directly supported research under the government programme, solar energy R&D in the UK has continued at universities and polytechnics, other research centres and within industry. The work at the universities and polytechnics is often funded by the Department of Education and Science through the Science Research Council.

Widespread solar heating research interest with industry has been demonstrated by the number of companies which have proposed joint research projects under the Government programme. Since the inception of the programme in February 1977, over 300 companies have applied to the Department of Energy for support for particular aspects of their research and development programmes. Although only 10% of the projects submitted were accepted as matching the needs and the priorities of the Government solar heating programmes, it is clear that much industrial research and development continues within the UK solar heating industry. The Solar Trade Association Limited has published a code of practice on solar water heating and the Heating and Ventilation Contractors Association has also issued a guide to good practice. The British Standards Institution's draft code of practice on solar heating systems for domestic hot water has been issued for

public comment.

3. CONCLUSION

Of the £16 million committed by the UK Government to research and development on alternative sources of energy, £6 million has been allocated to solar energy for a four-year programme which commenced in February 1977, £2.8 million of this is set aside for solar heating R&D. The industry has already committed over £1 million to the programme in jointly-funded projects and has substantial other solar heating R&D commitments. The UK national programme can be seen to be gathering momentum and making substantial progress.

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STATUS OF THE UNITED STATES' SOLAR HEATING AND COOLING PROGRAM

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Frederick H. Morse
Acting Director
Office of Solar Applications
Conservation and Solar Applications
United States Department of Energy

The United States Department of Energy (DOE) promotes the use of solar energy, a safe, clean, renewable resource, to alleviate the demand for expensive and increasingly scarce fossil fuels. The overall goal of the DOE Solar Heating and Cooling Program is to assist industry in commercializing solar energy systems for heating and cooling of buildings, for agricultural and industrial processes, and for Federal facilities.

In accordance with congressional legislation and the President's domestic energy policy, specific objectives of the solar heating and cooling program are (1) to reduce cost and improve performance of solar systems; (2) to collect, evaluate and disseminate data on solar systems; (3) to develop solar standards and performance criteria; and (4) to demonstrate solar heating and cooling by the close of the current fiscal year.

The program addresses two market sectors, buildings and industry, which account for 20 percent of U.S. energy consumption. The President's goal is to install 2.5 million solar energy systems in both residential and commercial buildings by 1985. At this rate, at least two percent of U.S. energy consumption can be met by the solar heating and cooling of buildings, and at least one percent by solar industrial process heating, by the year 2000. Stated another way, estimates for solar market penetration are 0.9 5.0 Quads for the buildings sector and 0.1 to 3.5 Quads for agriculture and industry totalling 9.4 to 18.1 Quads for all solar applications in the year 2000.

The major elements of the solar heating and cooling program are: research and development; residential and commercial demonstrations; agricultural and industrial applications; federal buildings program; technology transfer; and commercialization.

Research and development activities aim at improving the efficiency, lowering costs and extending the lifetime of advanced systems and components. The demonstration programs and agricultural and industrial applications programs apply existing technology to meet the thermal requirements of buildings and industrial and agricultural processes. The technology transfer and commercialization programs work in concert to stimulate market development forces of private industry and to accelerate the rate at which solar technologies become commercially available in various market sectors. Each of these programs is described in depth in the National Program Plan for Solar Heating and Cooling.[1]

Federal funding for the solar heating and cooling program in fiscal years 1978 and 1979 is shown in Table 1.

Table 1:
Solar Heating and Cooling Funding ($M)

	FY 78	FY 79
• Commercialization Planning and Assessment	1.4	2.7
• Research and Development	32.9	40.0
• Residential and Commercial Demonstrations	60.9	55.0
• Federal Buildings Program	20.0	25.7
• Agricultural and Industrial Process Heating	10.3	11.0
• Technology Transfer	2.6	16.6
	128.1	151.0

PROGRAM MANAGEMENT AND STRATEGY

The solar heating and cooling program is managed largely on a decentralized basis, with DOE headquarters providing program management. Responsibility for management of individual projects within various solar programs typically lies with DOE field offices. Technical support is provided by the Solar Energy Research Institute (SERI) and specific national laboratories selected according to their particular technical expertise. As commercial viability of solar products becomes established, technology transfer and market support will be provided, to a large extent, by SERI and the four regional solar energy centers throughout the U.S.

During the past two years, the Solar R&D program has grown considerably through a series of solicitations. The program maintains a balanced involvement of industry, universities, small businesses and governmental organizations, including five national laboratories (Argonne, Brookhaven, Berkeley, Livermore, and Los Alamos) and the Solar Energy Research Institute. In the past year alone (FY 78), a budget allocation of $31.9 million supported approximately 260 projects.

In the coming year, a new program strategy will be implemented to help establish a strong, competitive solar energy industry. This strategy supports industry (small and large firms alike) in the development of proven, economical, and integrated systems by following industry's traditional "product development sequence."

RESEARCH AND DEVELOPMENT

The current solar R&D program emphasizes active heating and cooling systems, passive heating and cooling systems, agricultural and industrial process heating systems, cost-effective components and systems analysis and design.

The projects initiated within each program element are briefly described below. More complete descriptions are contained in the Solar Heating and Cooling R&D Project Summaries[1].

Collectors (93 projects). Emphasis on air and liquid, flat-plate, and tubular-evacuated collectors; focusing and non-focusing concentrating collectors; materials; and analyses.

Thermal Storage (28 projects). Emphasis on sensible storage, phase-change storage, chemical storage, heat exchangers, and analyses.

Heat Pumps (14 projects). Emphasis on field tests, systems configuration analyses, and advanced designs.

Cooling (25 projects). Emphasis on absorption, Rankine/vapor compression, desiccant, heat pump, passive, photovoltaic, hybrid, and systems studies and analyses.

Systems (55 projects). Emphasis on controls, system simulation/validation, economic analyses, passive system development, and retrofit system development.

Passive (49 projects). Emphasis on physical studies and materials, product development, and system development.

DEMONSTRATION PROGRAM

The current DOE Solar Heating and Cooling Demonstration Program encompasses four areas:

- Residential demonstrations,
- Commercial demonstrations,
- Data program, and
- Standards and criteria.

Residential Demonstrations*

The Residential Demonstration Program provided an opportunity for builder-developers and solar energy systems manufacturers and distributors to demonstrate and market their solar energy systems. In this program, the builder-developer proposes the location, building type, and solar energy system as part of his application for a project and incorporates the proposed system into a complete residential project package. These integrated projects provide information on the constraints facing project developers in regard to market acceptance and other important operational and market matters. Some of these projects are also being instrumented for more detailed technical evaluation of the solar system.

To date there are 434 solar heating and cooling projects in the Residential Demonstration Program, involving nearly 12,000 dwelling units—initiated or in operation.

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* The Residential Demonstration Program is managed for DOE by the Department of Housing and Urban Development (HUD).

The fifth cycle is now underway, with grant applications now undergoing evaluation for awards of up to $2.8 million in FY 79.

In addition to the five RFGA cycles, HUD and DOE have sponsored a Hot Water Initiative and a Passive Design Competition and Demonstration. The Hot Water Initiative has resulted in the installation and funding of 3,500 solar water heating systems, with 3,000 additional systems currently being installed. The Passive Design Competition produced 242 awards: 17 retrofit design awards, 145 new design awards, and 80 awards to builders for the construction of new homes with passive features for sale on the open market.

A listing of the HUD residential demonstration projects through cycle three are contained in Solar Heating and Cooling Demonstration Project Summaries (DOE/CS- 0009).[3] Information on Cycle 4 and the Passive Design Competition will be available soon from the National Solar Heating and Cooling Information Center.[4]

Commercial Demonstration

Demonstrations of solar heating and cooling on both Federal and non-Federal commercial building applications, like the Residential Demonstrations, are being implemented in a cyclical manner to benefit from technological advances and experiences gained from previous projects.

The first PON (Program Opportunity Notice) cycle of the Commercial Demonstration Program began in the fall of 1975 with a call for proposals to incorporate solar energy in new or existing buildings, with primary emphasis on space heating and hot water systems. Thirty-one projects in twenty-two states and the Virgin Islands were selected from among 308 responses to the first cycle PON; 24 are now operational or in the operational test phase. The second demonstration cycle was initiated with the release of PON-2 in October 1976. This cycle accommodated a wider range of solar applications and building types and required specific attention to energy conservation techniques. Seventy projects in thirty-two states were selected from among the responses to the second cycle PON; 38 are now operational or in the operational test phase. The scope of the Commercial Demonstration Program was expanded with the release in May 1977 of a Hot Water Initiative for Hotel/Motel Installations. Thirty-one projects in twenty-seven states and the Virgin Islands were selected from among the 121 responses to the Hot Water Initiative PON; 11 are now operational or in the operational test phase. The third cycle was initiated with the release of a Program Opportunity Notice in November 1977 with awards made in 1978. Combined heating and cooling was emphasized equally with mandatory cost-sharing at an increased level expected for incremental solar system costs. To date, 274 commercial demonstration projects have been initiated in Federal and non-Federal buildings.

Solar Data Program

To facilitate data collection on representative solar demonstration systems, a central data processing facility was developed and began operation in October 1976. Currently 75 commercial demonstration projects, 75 residential sites and 39 operational test sites are planned to be instrumented for a full evaluation of their thermal performance. At present, 124 projects are transmitting engineering data to the central data processing facility for evaluation.

The collection and evaluation of data from the demonstration projects and their dissemination to a wide range of potential users are key objectives of the solar Demonstration Program. These data must be readily understood by users so that they can be applied to decisions as to the selection and application of solar energy systems. Special emphasis is therefore being placed on the determination of user needs, standardization of data to allow system comparison, and close inter-agency coordination to minimize duplication of activities.

Standards and Criteria

Standards and criteria for solar system and subsystem design and performance are vital to reduce the uncertainties inherent in any new technology and provide a basis for adequate consumer protection, promote competition, and contribute to product improvement. Federal agencies, including DOE, HUD, and the National Bureau of Standards (NBS), are cooperating with other organizations in the development of consensus standards, a system extensively utilized by all levels of government and industry in the United States.

Interim performance criteria developed for both residential and commercial solar energy systems have been issued and will be updated as necessary to incorporate experience gained through the Demonstration Program. Definitive performance criteria for both commercial and residential applications will be published in the near future. Intermediate Minimum Property Standards for

solar heating and domestic hot water systems were developed in July 1977, by HUD.[4] These standards apply to all housing built under programs of the Federal Housing Administration, Farmers Home Administration, and Veterans Administration. A program is being conducted through the Solar Energy Research and Education Foundation (SEREF), which is under contract to DOE, to develop proposed procedures and criteria for solar collector rating, labeling, and certification program in accordance with consensus tests and standards.

Other activities include the development of the Model Document for Code Officials on Solar Heating and Cooling of Buildings, intended for adoption into state and local building codes; and the DOE Interim Solar Collector Testing Program, in which over 160 commercially available collector models are being tested for thermal performance using the consensus standard test method, developed by the American Society of Heating, Refrigeration and Air Conditioning Engineers.

FEDERAL BUILDINGS PROGRAM

The Department of Energy's Solar in Federal Buildings Program (SFBP) is a $70 million program designed to stimulate growth and improve the efficiency of the solar industry by demonstrating the Government's confidence in and support of the industry. The overall program goals are to provide assistance to Federal agencies over a three-year period with the design, acquisition, construction, and installation of solar equipment in Federal buildings.

Through the demonstation of solar heating and cooling in new and existing Federal buildings, the program aims at obtaining maintenance and operating experience, system and installation costs. The program relies on available solar technology and, ultimately, should encourage more rapid commercialization of solar heating and cooling. The anticipated program budget through fiscal 79 is $45.7 million, with approximately 30 percent of funds expected to be used for hot water, 60 percent for space heating, and 10 percent for space heating and cooling solar applications.

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT (A&IPH)

To date, the A&IPH program has funded 18 different industrial process heat projects divided into three categories: hot air, hot water and industrial steam processes. Seven projects are operational and four more will be dedicated during 1979. The A&IPH program has also developed a strong interest in solar-enhanced oil recovery. In this process, a solar system generates steam which is injected into the ground to displace secondary and tertiary oil. Awards for feasibility studies and preliminary designs of solar-enhanced oil recovery projects will also be made by the end of 1979.

A cooperative program is established between DOE and the United States Department of Agriculture—Science and Education Administration for research and development of solar energy systems suitable to on-farm applications. Current experiments include solar drying of grains and crops, solar heating of greenhouse/residence combinations and likestock shelters, and solar applications in food processing. The A&IPH program currently funds 57 different solar agricultural projects in 29 different states.

The A&IPH future program plans are to continue the recommendation and implementation of Federal legislation for solar financial incentives. Several additional demonstration projects will be funded for low-temperature applications in agriculture and industry in 1980 and 1981. Funding for the construction of several intermediate-temperature industrial process heat systems will also continue through 1980 and 1981. A detailed description of Agricultural and Industrial Process projects is contained in Solar Energy for Agricultural and Industrial Process Heat.[5]

TECHNOLOGY TRANSFER

Technology Transfer links Solar Energy Research, Development, and Demonstration Program with the utilization of its proven technology by the solar industry and the public. In 1977, the Solar Technology Transfer Program was established to provide public and private organizations with resources that amplify the program efforts.

The following Technology Transfer activities are underway: development and implementation of a broad range of installer training and educational programs; assistance to the industry implementation of solar; installer licensing and certification procedures; stimulation of the utlization of solar energy linked with the development of jobs and small businesses in economically deprived communities; dissemination of user-oriented information, such as documents and public media material; support of exhibits, workshops and conferences; identification of target opportunities for

technologies with potential for accelerated commercialization; development and implementation of a consumer representation plan; and development of an international program aimed at less-developed countries.

COMMERCIALIZATION

The overall objectives of the Commercialization Program are: (1) to develop the National Plan for the Accelerated Commercialization of Solar Energy; (2) to identify and evaluate barriers to the development and commercialization of solar energy—economic, social, legal, institutional, and regulatory; and (3) to recommend policies to remove barriers and accelerate solar commercialization.

The major Commercialization Program elements are: solar commercialization planning; economic modeling and analysis; economic and financial incentives; public utility/solar energy interface; legal, regulatory, and institutional issues; employment and manpower issues; marketing and consumers issues; regional, state and local issues; and international market analysis.

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